The impact of computer simulation on Welsh industry.

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The impact of Computer Simulation on Welsh Industry

By

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Summary of the Research

The motivation behind the research was to assess the utilization and impact of computer simulation on Welsh industry. The study included an analysis of the financial investment made by the Engineering and Physical Science Research Council in computer simulation. The main thrust of the research was an in-depth analysis of data obtained from a questionnaire sent to 1000 Welsh companies.

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Chapter 1

1.1 Motivation for the Research

The motivation behind the research was to assess the utilization and impact of computer simulation on Welsh industry. The study included an analysis of the financial investment made by the Engineering and Physical Science Research Council in computer simulation. The main thrust of the research was an in-depth analysis of data obtained from a questionnaire sent to 1000 Welsh companies.

1.2 Background of Computer Simulation

1.2.1 Manufacturing in the UK and the Potential Impact of Computer Simulation

"Manufacturing is by far the largest single contributor to the global economy accounting for nearly three-quarters of the World's trade. It is a significant component of the UK economy. It adds to the well being of the nation by fundamentally affecting employment, wealth creation, international standing and quality of life. Manufacturing generates two-thirds of the value of the UK's exports, directly provides 4.3 million jobs and accounts for 20% of GDP. In certain regions, the manufacturing sector is the major employer.

However, what is often overlooked is that other sectors in the UK are interlinked with manufacturing and could not exist without it. Many service sectors, such as wholesale and retail distribution, maintenance and after-sales, have manufactured goods as their *raison d'être* – and these services contribute further to GDP. So the proportion of GDP that depends on manufacturing is greater than the 20% figure mentioned above.

UK manufacturing is an important part of the global knowledge-driven economy. The UK plays a leading role in a number of sectors, such as pharmaceuticals and aerospace. In addition, the profitability of UK manufacturing increasingly depends on high value-added output, so manufacturers are constantly looking to develop and exploit new and specialised knowledge"[1].

New and specialised technology takes many forms, however, the advent of the computer has had a major impact on industry and commerce. Computers can be used in many different ways, including word processing, data acquisition, product manufacture and communication.

As a result of an increase in product complexity and economic constraints, there has been a demand for greater efficiency, where industry has to invest in more innovative ways to assist design and manufacture. With the help of "Computer Modelling and Simulation" industry has a tool that is very likely to enable it to meet its targets [2].

1.2.2 The Technique of Computer Simulation

Computer simulation involves solving problems by describing the problem in terms of mathematical equations and then solving the equations on the computer. Computer simulation is a very powerful tool to assist in design and manufacture as it enables the designer to better understand a design or the processes involved. It can be used in weather forecast, financial modeling, management procedure, traffic control, heavy structure design, nuclear testing and aerospace design. However, the research reported here concentrates on the use of "computational engineering" or computer simulation related to engineering in general.

Details of the procedures involved in the computational engineering may vary substantially from one application to another. In general, a mathematical description for both of the configuration and the examined physical phenomena represents the "computational model". Typical uses of such models usually provide a satisfactory level of approximation to what may happen in the real world. Thus, engineers can carry out a number of analyses during the design phase until an optimum solution is found. Also, failing cases of an in-use design can be investigated in order to avoid future design problems.

The use of computational engineering is not limited to the traditional types of engineering problems any more- see Figure 2 where two typical examples of automotive and aerospace industry are presented. It has been introduced into a wide

range of disciplines such as biomechanical; Figure 1 illustrates a set of computer models that have been used in different biomechanical studies.

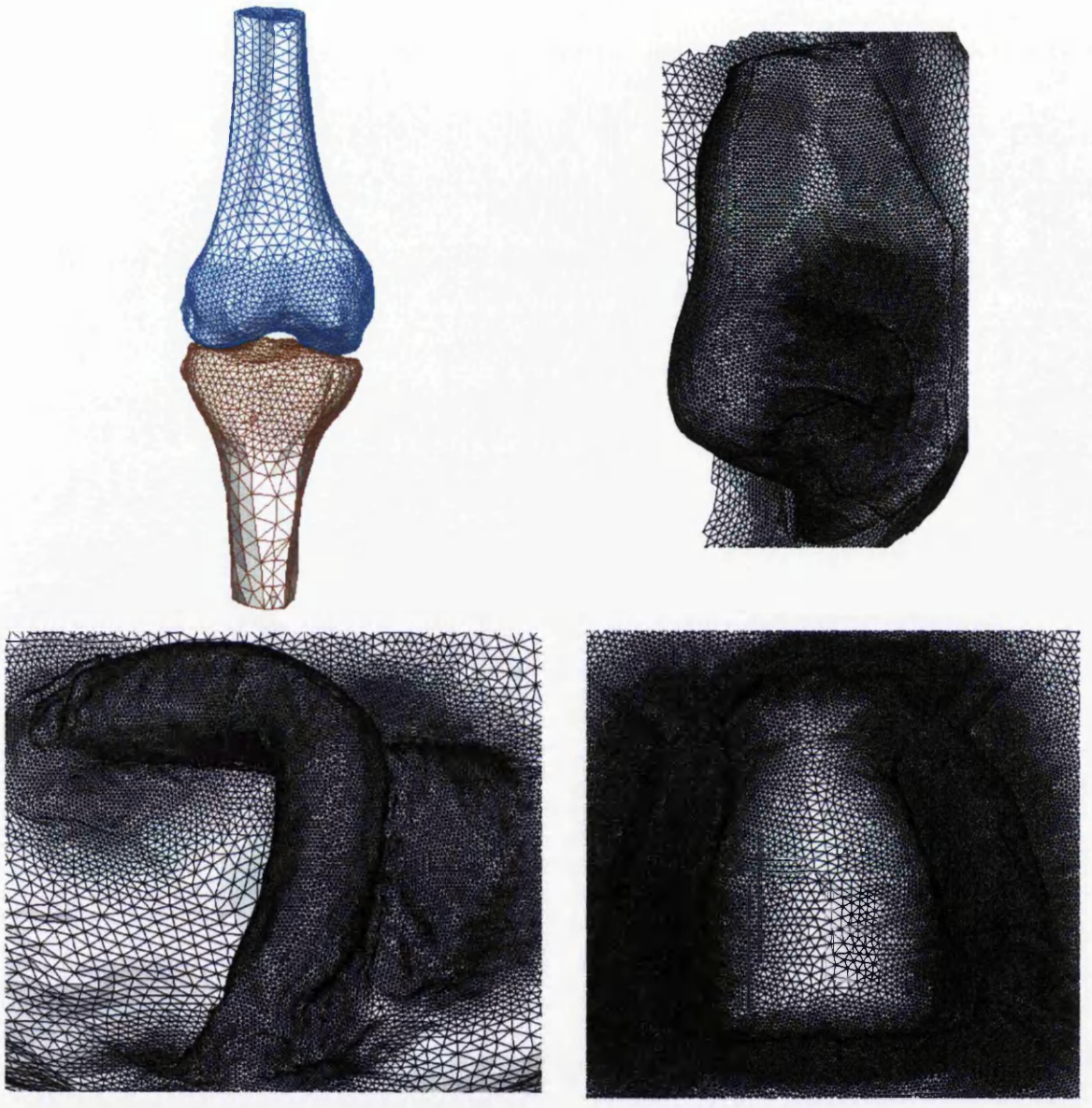

Figure 1 A computer model of different biomechanical applications: (a) bones in a human knee joint, (b) outer surface of a nose, (c) and (d) two models of dental prosthesis.

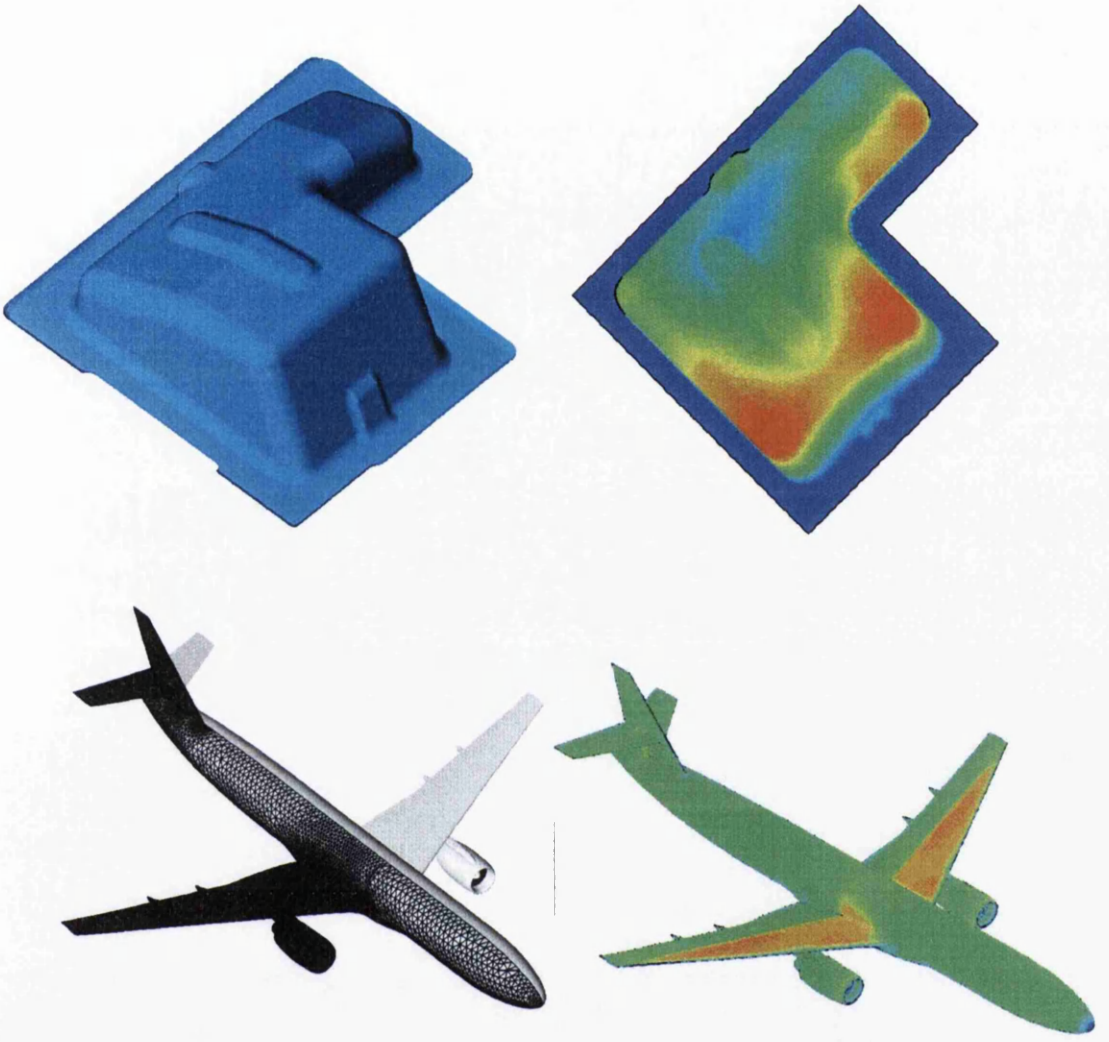

Figure 2 **(a) A computer model of an Aluminium sheet formed into a sump pan, the colour contours represent the thickness distribution. (b) A computer model of a civilian aircraft used in aerodynamic analysis, a contour of the pressure distribution on the surface is presented.**

1.2.3 Computer Simulation; Advantages and Disadvantages

From an industrial viewpoint, the advantages and disadvantages of computer simulation must be considered and weighed against each other.

Industry can gain four big advantages in the use of computer simulation:

- Computer simulation is a good investment, when used efficiently.
- It is cost effective, especially in the long term, and compared with experimentation.
- It is environmentally friendly, as it causes no harm whatsoever to the environment.
- It uses the latest technology that has a promising future. It has the potential to assist in new scientific breakthroughs.

On the other hand, there are two disadvantages for industry:

- Computer simulation can be very expensive especially for small businesses.
- It requires highly qualified people who cannot be found easily.

1.3 The Welsh Economy with its Special Features

1.3.1 Background of the Welsh Economy

Wales, today, has little remaining from its recent industrial past. Employment in the coal industry is very low compared to some overseas electronics plants and output in metals industry is highly concentrated in two steel plants. At the beginning of the 1980s, Wales had a serious problem in its economic and social structure. On the one hand, it was the decline in the coal and metals sectors; on the other, there was a decline in some older manufacturing sectors that were related to both the coal and metals industries. As a result, Wales entered the decade as one of the poorest areas in the UK, scoring badly on many different economic indicators.

There was a real economic transformation in the 1980s. This came about as a result of physical infrastructure development and foreign capital. In fact, Wales managed to be one of the best regions in the EU at attracting overseas investment throughout 1980s and early years of 1990s. Old coal and metals industries have been replaced by

the electronics, automotive and chemicals industries with investment from some American, European and Japanese multi-nationals. Also, the services sector has started to contribute more and more to the Welsh economy by attracting financial and business service companies in call centre investments.

Without the industrial and physical infrastructure changes in the last two decades of the twentieth century, and the investment of new industries, Wales would have been much poorer. At the beginning of the new Millennium, Wales is still behind compared to other UK regions when key indicators such as gross domestic product (GDP) per capita, and average earnings are considered. For example, the last GDP per capita estimate in Wales was just 82% of the UK average, while average earnings is 10% less than the UK average. That shows how the changes in the last two decades were still not sufficient to narrow the prosperity gap with other UK regions. Moreover, there is a large diversity of economic prosperity within Wales itself. Whereas the South East centred on Cardiff and Newport, is a prosperous area when compared to the South Wales valleys, West Wales and North West Wales, enter the new Millennium by being eligible to EU Objective 1 status as they are classed as one of the poorest regions within the European Union [3].

❑ About the European Structural Funding

"Wales is now eligible to receive European Structural Funding under Objectives One, Two and Three. Together, these funds are designed to support a wide spectrum of activities to promote the economic and community development of targeted European regions. Each of the three objectives focuses upon a particular kind of structural need.

- Objective One: Promotes the development and structural adjustment of regions whose development is lagging behind, defined as regions whose GDP per head is less than 75% of EU average.
- Objective two: Supports the economic and social conversion of areas facing structural difficulties.
- Objective three: Supports the adaptation and modernisation of education, training and employment policies and systems" [4].

❑ Objective 1

Objective 1 provides high levels of aid to enhance the wealth creation potentiality of targeted regions. It applies to poor areas, as was mentioned before, where wealth creation per head falls under 75% of the European average.
The aim of Objective 1 is to improve the evolution and structural adjustment of these regions so that they have better economic growth.

Large parts of North and West Wales, besides the Valley areas, qualify for Objective1 funds. This makes them eligible for this huge financial support in the years 2000 - 2006. Over these six years, a budget of nearly £1.2billion allocated by EU Structural Funds is supposed to be invested in a wide range of programmes and projects.

This can include projects to increase and evolve the smaller company base, develop innovation to sustain a knowledge- based economy, develop people, strengthen communities, enhance rural development activities and make needy areas an attraction for investment and jobs.

Hereby, all projects must address one of the top priorities set up by the Objective 1 programme.

- Developing and expanding the small and medium sized enterprise (SME) base.
- Developing innovation and the knowledge-based economy.
- Community economic regeneration.
- Developing people.
- Rural development and the sustainable use of natural resources.
- Strategic infrastructure development [5].

❑ Objective 2

"The aim of the Objective 2 programme is to help areas hardest hit by industrial decline to create a new economic base.
This funding has already been used in many parts of Wales, which suffered from the loss of jobs in the steel and coal industries.
Objective 2 applies in a number of Unitary Authority areas, through mid and eastern Wales. These are areas where the unemployment rate is higher than the

European average or the proportion of people employed in industrial jobs is above the EU norm" [6]

❑ Objective 3

"This programme aims to boost the skills, competitiveness and employability of people in target regions and areas. In particular, it combats long-term unemployment and assists young people and others who are at risk of being excluded from the workforce.

Objective 3 projects also promote equal access to education, training and employment opportunities and seek to improve women's position in the workforce.

It also aims to generate greater adaptability and entrepreneurship in the workforce and to promote lifelong learning through better education, training, counselling and guidance"[7]

1.4 Aims and Objectives of the Work

In order to assess the utilization and impact of computer simulation in Welsh industry there was a need to:

- Assess the interest of the government science body represented by the Engineering and Physical Science Research Council in projects related to computer simulation
- Decide the extent of the involvement of Welsh companies with computer simulation
- Decide upon the strength of communication between Welsh industry and universities

1.5 Overview of the Research

The research was built on collecting data from different sources and detailed analysis. The first stage of this research has been the collection of data related to EPSRC grants. The following EPSRC programs were the source of the data:

1. Mechanical Engineering program 1996
2. Control and Instrumentation program 1996
3. Design and Integrated Production program 1996
4. General Engineering program1997

This data then was used to provide an indication of the level of funding on work related to computer simulation. The next stage involved the preparation of a questionnaire that was sent to 565 companies in North Wales and 435 companies in South Wales, making a total of 1000 company. The aim of the questionnaire was to determine how widely used technology related to computer simulation was utilized with Welsh industry.

1.6 Overview of the Questionnaire

The aim of the questionnaire was to obtain some guiding figures from Welsh companies that would indicate their involvement with computer simulation. It consisted of 10 questions. These questions covered awareness of computer simulation as well as company turnover, gross profits and employees. Companies, also, were asked about their expenditure on software & maintenance, hardware & maintenance and about their R&D budget. Finally, there were questions about the provision, investment and evaluation of computer simulation.

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Chapter 2

2.1 Analysis of Funding by EPSRC

The engineering and Physical Science Research Council uses its allocated funds to support research into areas of engineering that may be beneficial to industry. The assessment of areas for investment is performed by expert panels, input from industry and universities and the conclusions from government initiatives such as Foresight.
As a relevant component of this research, it was necessary to determine the approximate level of funding for EPSRC into the area of computer simulation. If the level of funding was determined to be high, this would clearly indicate that a high priority was given to this activity. However, if the funding level was low, little emphasis was given to this area, and hence deemed a low priority

2.2 The Engineering and Physical Science Research Council

2.2.1 Introduction

"EPSRC is the largest of the seven research councils responsible for promoting and supporting basic, strategic and applied research for the UK.

The UK research councils are autonomous, non-departmental public bodies principally funded from the science budget received from the Office of Science and Technology. They support research, study and training in universities and other higher education establishments, their own institutes and international research centres. The professional staffs of the research councils includes a full-time Chief Executive of proven scientific distinction and a part-time Chairman to contribute industrial and commercial experience.

The other Research Councils are:

- Biotechnology and Biological Sciences Research Council
- Economic and Social Research Council
- Medical Research Council

- Natural Environment Research Council
- Particle Physics and Astronomy Research Council
- Council for the Central Laboratory of the Research Councils" [1]

2.2.2 The EPSRC Mission

On its web site, EPSRC defines its mission as:

- Supporting and encouraging high quality postgraduate research and training in subjects related to engineering and physical science;
- Contributing to the British economy, by improving knowledge and technology, and providing trained engineers and scientists to the industry;
- Providing advice, spreading knowledge and boosting public knowledge in related fields

2.2.3 THE ROLE OF EPSRC

To follow its mission, EPSRC, has to make strategy, determine its plans, and set up its priorities. EPSRC also takes advice from two independent panels: The Technical Opportunities Panel (TOP) and the User Panel (UP). Also EPSRC is supposed to send an annual account report to Parliament.

2.2.4 The Role of the Technical Opportunities and User Panels

According to the EPSRC web site, the essential role of TOP is recognising new research opportunities in mainstream and interdisciplinary areas. The Technical Opportunities Panel's members are mainly chosen from the academic sector. UP is considered the EPSRC user community, which advises on the EPSRC research needs and the value of its output. The main members of UP are chosen from the EPSRC user sectors: industry, commerce, government and education sectors.

2.2.5 EPSRC and Industry

EPSRC announces on its web site that with a total budget of nearly £380 million per annum it is responsible for supporting and funding research and postgraduate training in areas related to engineering and the physical sciences.

- **What are the mechanisms for industrial involvement?**

Although, EPSRC target funding into universities, industrial collaborators are also very well supported by EPSRC. Many projects of EPSRC involve industry,

Through collaborative research;

Relevant postgraduate training;

People exchange.

- **What does industry gain from EPSRC?**

- The next generation of scientists and engineers of young and highly qualified post-graduate or post-doctoral researchers.
- Access to very advanced facilities and instrumentation, as well as great expert advice and consultancy.
- An influence on EPSRC research fund, besides collaboration on its research projects.
- An influence on EPSRC's research and training portfolio.

The following figure reflects the important role of universities, through EPSRC activities, in providing industry, commerce and government sectors with highly qualified people.

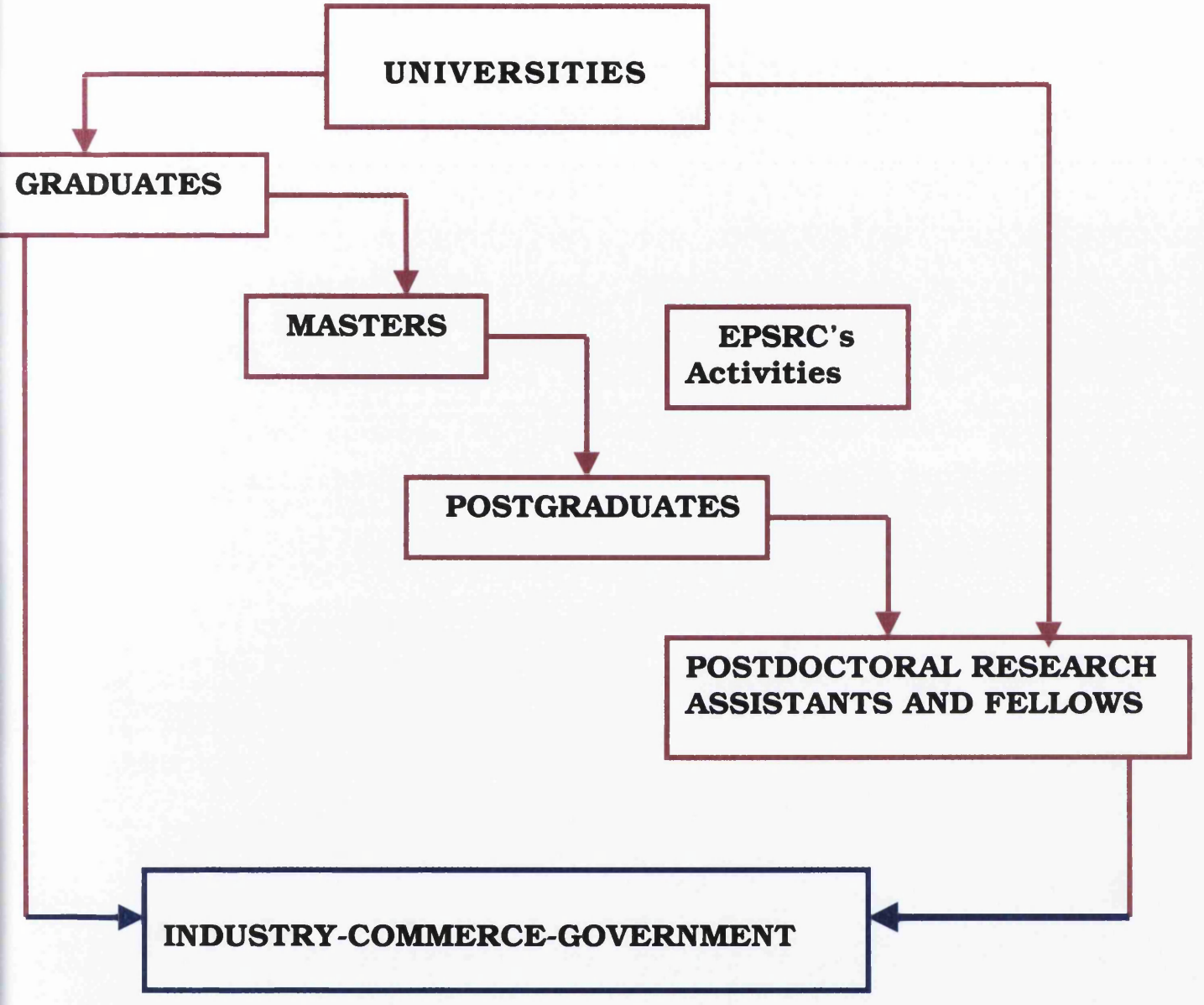


Figure 3 Transforming of knowledge, expertise and technology through the movement of people [1].

2.3 Foresight Panels

2.3.1 The Purpose of Foresight Programme

On its web site Foresight talks about the purpose of its programme:
"The future is shaped by decisions we make today. No one can predict the future. What we can do is look ahead and think about what might happen so that we can begin to prepare for it today"[2].
In order to build a better communication, the Foresight programme brings business, the public sector, the science base and others together, so that threats, needs, changes and opportunities over the next two decades can be recognised in advance. The aim is to increase prosperity, improve the quality of life for all and introduce a culture change where business and the science base are well connected.

The Foresight Programme managed by the Office of Science and Technology (OST) within the Department of Trade and Industry (DTI) was launched at 1994. The new round of five years started in April 1999 with ten sectoral and three thematic panels. Each of these panels studies the future from a particular angle. The panels do their work through task forces and take each other's results into account. A huge amount of work is underway. The results are presented into scenarios, trends, information and recommendations, all regarding the future, and all for the benefit of organisations everywhere. Also, Foresight has built up new networks and partnerships with different sectors and disciplines [2].

2.3.2 Foresight and the Higher Education

The Foresight programme's web site suggests that Higher education is going through a very unique stage. The high knowledge based economies pressurise higher education to work side by side with business, by providing well-trained and highly qualified people who will form the future workforce. Thereby, Foresight supports the Higher education sector in addressing these issues.

Universities, through Foresight, are trying to have a more effective and practical relationship with business and industry. Baroness Warwick the Chief Executive of

the Committee for Vice Chancellors and Principals and a member of the Foresight Steering Group, remarks, "Foresight has brought people together – academics and business people – who would not otherwise have had occasion to exchange views. The result has been a stimulating cross-fertilisation, important in promoting multi- and interdisciplinary work."

Foresight is playing an important role in helping the higher education sector to achieve a real culture change, the signs are quite positive even though the promotion is still in its early stage. Universities, these days, are debating on the directions that research should take as many Research Councils funds start to comply with Foresight priorities.

2.3.3 Foresight and the Research Councils

Foresight, also, has been behind the fact that all Research Councils should work closely together. Research Councils never witnessed this way of communication. The aim is to focus on the future needs of the science base in terms of instrumentation and technology.

The Particle Physics and Astronomy Research Council (PPARC) is leading the Foresight programme, "The Long Term Technology Review (LTTR)". This programme has built bridges between the seven Research Councils in order to identify the kind of technological challenges researchers are likely to experience within the next decade.

Each of the Research Councils has been looked at by LTTR, separately, to decide the long-term needs of all sectors. Later on, results were gathered in order to reach a single comprehensive map that helps find the way to the future technological requirements of UK science. These conclusions will be available to the Foresight Panels and industry as a later stage.

All Research Councils are hoping that stronger partnerships between business and the science base and across all sectors and disciplines will be introduced by LTTR, through the Foresight Programme [2].

2.4 The Analysis of EPSRC's Research Programmes

In this first stage of the research, data of EPSRC grants have been chosen from four programs. These programmes are:

1) Mechanical Engineering Research 1996[3].
2) Control and Instrumentation Research 1996[4].
3) Design and Integrated Production Research 1996[5].
4) General Engineering Programme Research 1997[6].

2.4.1 Data Analysis

The idea behind analysing EPSRC grants' data was to assess the level of support given, by EPSRC, to projects involved with computer simulation.

Analysis of EPSRC programs included

a. Classifying projects in computational and non- computational areas.

b. Determining the value of grants per year for each project.

c. Applying some descriptive statistics and frequency on the data obtained –to help determine data distribution.

d. Using graphs to show a comparison between size and number of computational and non-computational engineering grants allocated in these four programmes.

2.4.2 Descriptive Statistics

- **What are Statistics?**

"The subject "statistics" is concerned with collecting reliable data and then analyzing and interpreting them" [7].

- **Descriptive Statistics Analysis Tool**

For summarizing EPSRC data, some simple methods under the title "Descriptive Statistics" have been used. This analysis tool generates a report of univariate statistics for data in the input range. Providing information about the central tendency and variability of data.

"Any quantity that is calculated from the data is a statistic. Thus a statistic is a function of the measurements or observations. Most statistics can be divided into two types: Firstly quantities which are 'typical' of the data and secondly quantities which

measure the variability of the data. The former are usually called measures of location and the latter are called measures of spread"[7].

a. Measures of Location

- The mean. It is one of the three most commonly used measures of location. It is also the most important. For n observations $x_1, x_2, x_3, \ldots\ldots x_n$ of the variable x,

$$\bar{x} = \frac{x_1 + x_2 + x_3 + \ldots\ldots + x_n}{n} = \frac{1}{n}\sum_{i=1}^{n} x_i \text{ [7].}$$

- The median. If the n observations are in ascending order of magnitude, then the median is the observation at location (n + 1) / 2. Half of the observations are smaller than the median and half are greater [7].

- The Mode. This is the value of the variate with the greatest frequency. However, the mean, mode and median can be very close if the distribution of results is roughly symmetric [7].

b. Measures of spread

On the other hand, it is very important to see how far the data is spread out.

- Range. It is the difference between the largest and smallest observation.
- The variance. For n observations $x_1, x_2, x_3, \ldots, x_n$ the sample variance s is:

$$s^2 = \sum_{i=1}^{n} \frac{(x_i - \bar{x})^2}{n-1}$$

- The standard deviation is a measure of how widely values are dispersed from the average value, the mean, and it is the square root of the variance

$$s = \sqrt{\frac{1}{(n-1)}\sum_{i=1}^{n}(x_i - \bar{x})^2}$$

Because the range tends to get larger when the size of the sample increases, and depends only on two outlaying values, it cannot be considered as a reliable measure of spread on its own. However, it can provide a general guide to the values that standard deviation is likely to have. Particularly, the value of s must always be less than the range. This guide can be used for a roughly symmetric distribution:

s ≈range/(n) for n<about 12

s ≈range/4 for 20<n<40

s ≈range/5 for n about 100

s ≈range/6 for n about 400

When distributions are skewed, standard deviation tends to get a somewhat large ratio of the range [7].

c. Some other measures.

Skewness. It presents the degree of a symmetry distribution around its mean. Positive skewness indicates a distribution with a symmetric tail extending towards values that are more positive. While negative skewness indicates a distribution with a symmetric, tail extending towards more values that are negative.

$$\text{skew} = \frac{n}{(n-1)(n-2)} \sum_{i=1}^{n} \frac{(x_i - \bar{x})^3}{s^3}$$

Kurtosis. It presents the relative peakness or flatness of a distribution. Relatively peaked distribution will have positive kurtosis while relatively flat distribution will have negative kurtosis.

$$\text{Kurtosis}=\left\{\frac{n(n+1)}{(n-1)(n-2)(n-3)} \sum_{i=1}^{n} \left(\frac{x_i - \bar{x}}{s}\right)^4\right\} - \frac{3(n-1)^2}{(n-2)(n-3)}$$ " [7].

o Graphical methods

"It is always a good idea to plot the data in as many different ways as possible, as much information can often be obtained just by looking at the resulting graphs.

- The bar chart. This diagram is used with discrete data. The first step is to find the frequency, so that frequency distribution can be plotted as bars.
- The histogram. The histogram is used to display continuous data. Like the bar chart it reveals the general pattern of the data as well as any unusual values or outliers.
- The cumulative frequency diagram. Another useful way of plotting data is to construct what is called a cumulative frequency diagram" [7].

2.5 Mechanical Engineering Research Program 1996

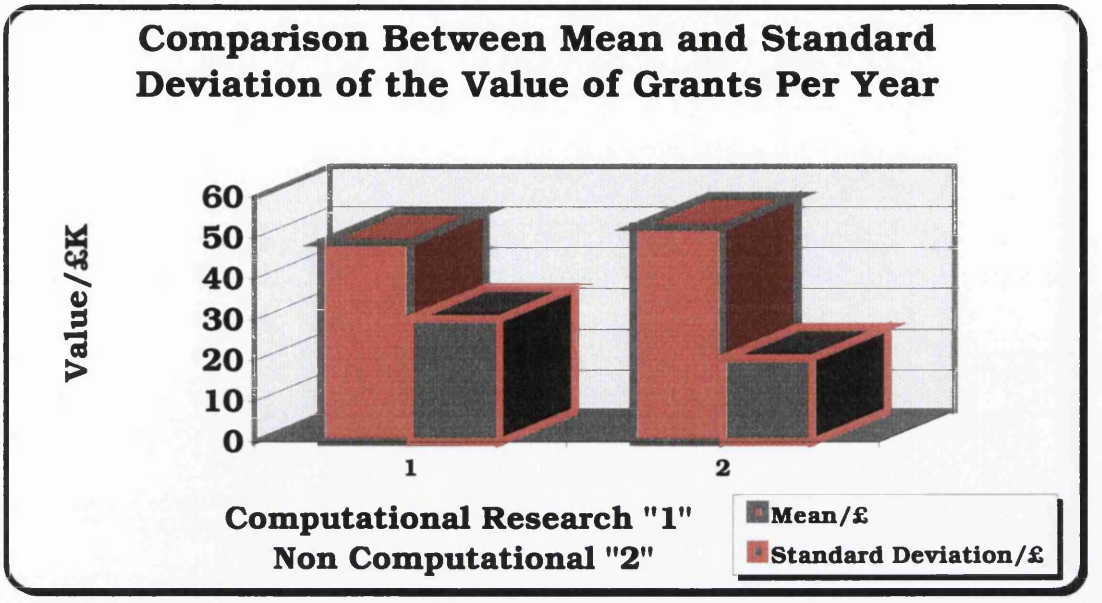
- Table 1 shows some descriptive statistics of the Mechanical Engineering Research data- see Appendix1. The following graphs highlight the important differences between the two sets of statistics for both computational engineering and non-computational engineering research data.

Descriptive Statistics	Computational Research	Non Computational Research
Mean/£	48927	52758
Median/£	42928	49859
Mode/£	0	#N/A*
Standard Deviation	30306	20620
Sample Variance	918456461	425174071
Kurtosis	12.2	0.6
Skew ness	2.6	0.4
Range/£	226697	111913
Minimum/£	0	1338
Maximum/£	226697	113251
Sum/£	6409411	4695498
Count	131	89

Table 1 Descriptive Statistics of Computational and Non-Computational Research Grants of the Mechanical Engineering Research Programme 1996

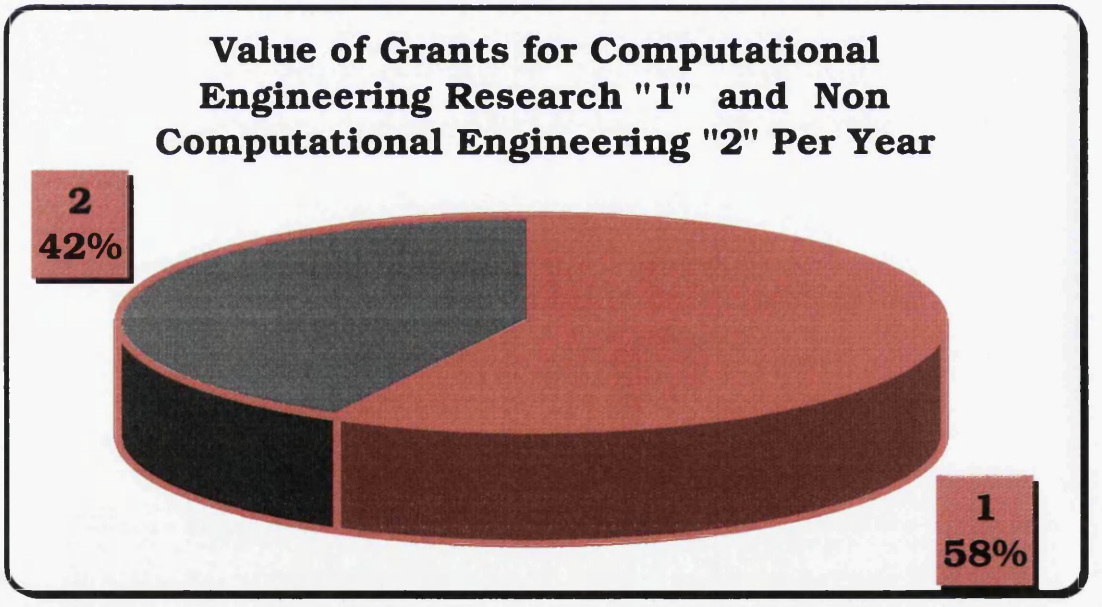
- In Graph 1, firstly, the mean of non-computational research grants is higher than the mean of computational engineering grants. Also, the median in Table 1 is higher in non-computational research grants. This suggests, in general, that grants in computational engineering are of less value than other grants.

Furthermore, the standard deviation of the grants for computational engineering is, noticeably higher which, again, shows the value of other grants to be wider dispersed from the mean than what it is with non-computational grants.



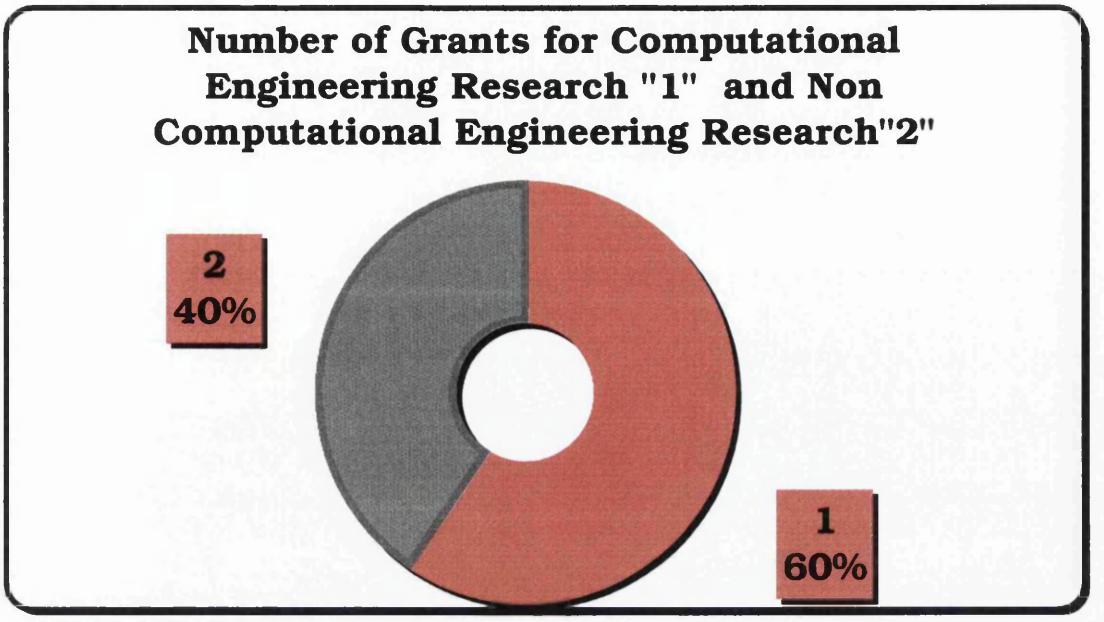
Graph 1

- However, it is different matter in Graph 2 where the share of computational engineering research fund is around 58% of the whole Mechanical Engineering Research Program funding for year 1996.



Graph2

- Similarly, Graph 3 reveals that the number of grants for computational engineering in the Mechanical Engineering Program 1996 is larger (60%) compared to the non-computational engineering grants.

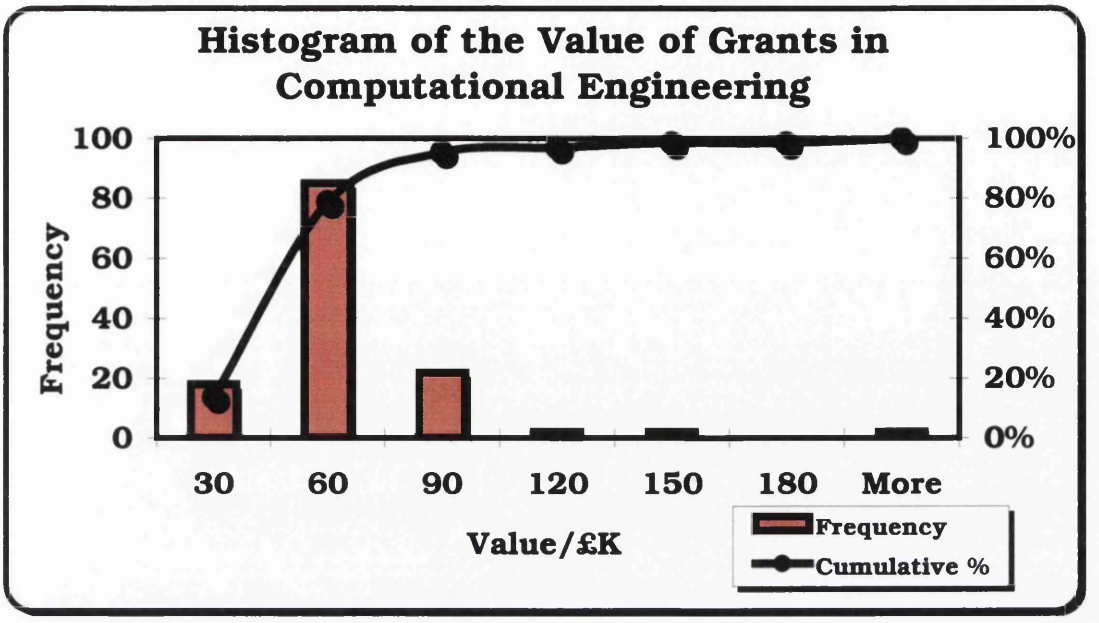


Graph3

- Now, using the cumulative frequency histogram for plotting the grants for Mechanical Engineering help confirm the previous points. Table 2, and Graph 4 together show that nearly 80% of the grants of computational research do not exceed £60,000, where grants values are widely dispersed from the mean. Graph 4 also shows this histogram, relatively skewed to the right and peaked. This, in fact, reflects the big differences between the values of grants in this set.

Value/ £K	Frequency	Cumulative %
30	18	14%
60	85	79%
90	22	95%
120	2	97%
150	2	98%
180	0	98%
More	2	100%

Table 2 The Cumulative Frequency Histogram of the Value of Grants in Computational Engineering of Mechanical Engineering Research Programme.

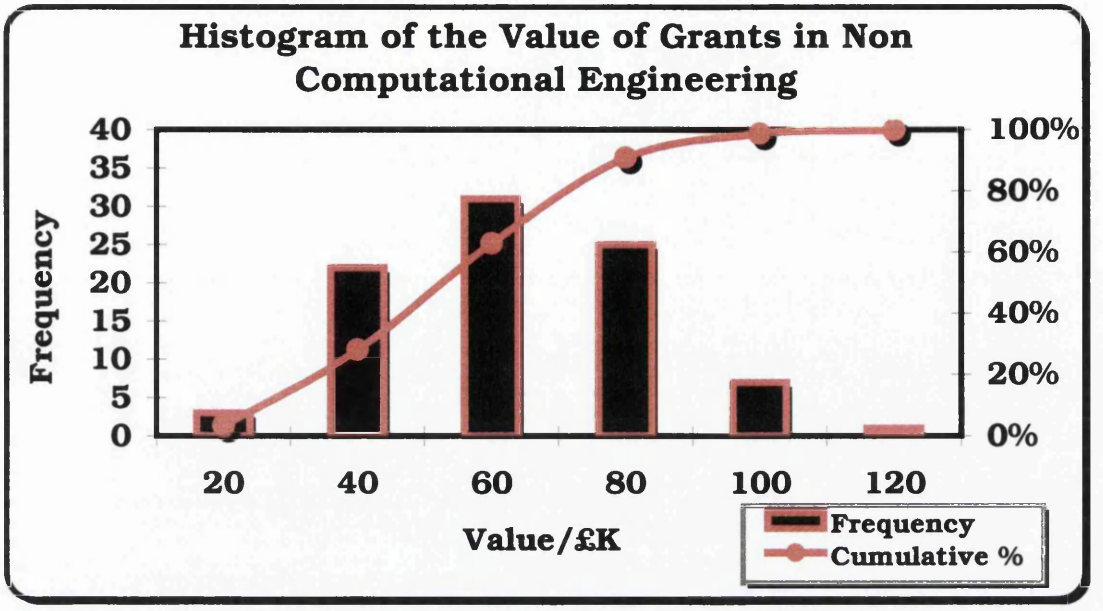


Graph 4

- Table 3 and Graph 5 show that almost 91% of non-computational grants are up to £80, 000, which is a higher value than computational engineering grants as was mentioned earlier. The histogram is nearly symmetric and flat. This suggests the differences between grants in terms of value are not so large.

Value/ £K	Frequency	Cumulative %
20	3	3%
40	22	28%
60	31	63%
80	25	91%
100	7	99%
120	1	100%

Table 3 The Cumulative Frequency Histogram of the Value of Grants in Non-Computational Engineering of Mechanical Engineering Research Programme.



Graph 5

2.6 Control and Instrumentation Research Program 1996

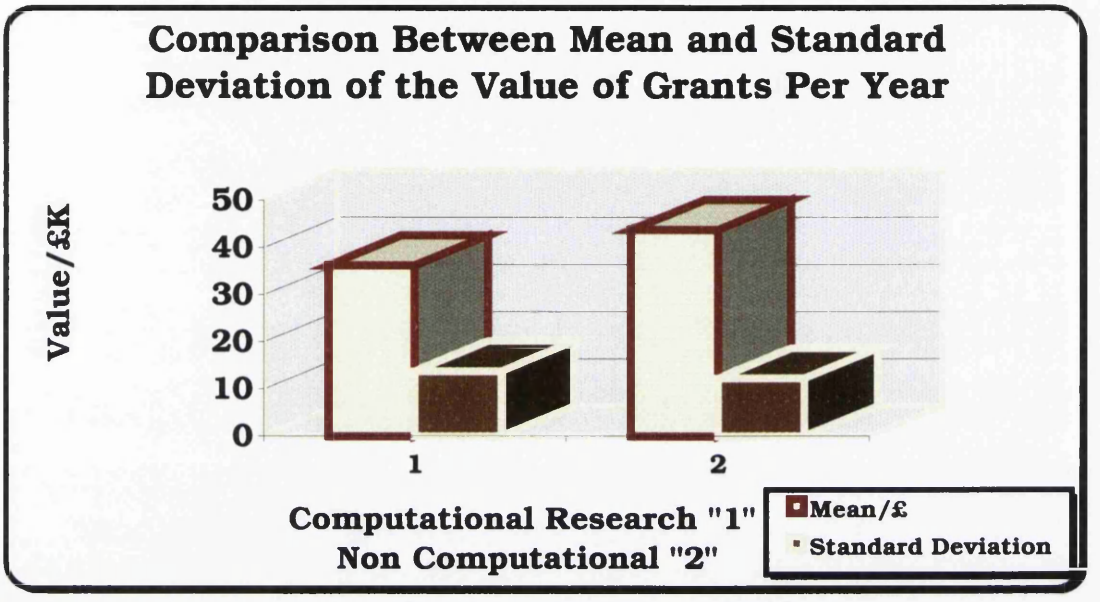
- In Table 4, these descriptive statistics are for both sets of grants that were allocated within the Control and Instrumentation Research Program for the year 1996- see Appendix2.

Descriptive Statistics	Computational Research	Non Computational Research
Mean/£	36143	43653
Median/£	33271	41997
Mode/£	#N/A	#N/A
Standard Deviation	13825	12286
Sample Variance	191128940	150944271
Kurtosis	1.6	1.3
Skew ness	1.0	0.4
Range/£	68907	72591
Minimum/£	8571	8951
Maximum/£	77478	81542
Sum/£	1734862	2444563
Count	48	56

Table 4 Descriptive Statistics of Computational and Non-Computational Research Grants of the Control and Instrumentation Research Programme 1996

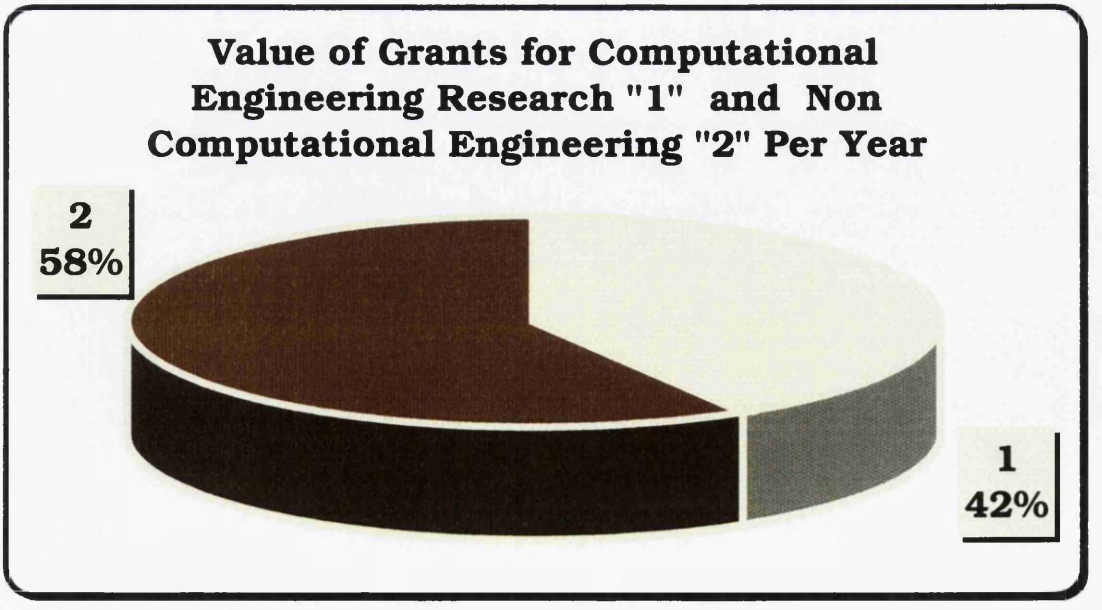
- Graph 6 shows that the mean of non-computational engineering grants is larger than the mean for computational engineering grants. The value of the median for both groups do not disprove this point, which means the grants of non-computational research are of a higher value for this program as well.

The standard deviation in Graph 6 is slightly larger for grants of computational engineering than it is for non-computational engineering grants.



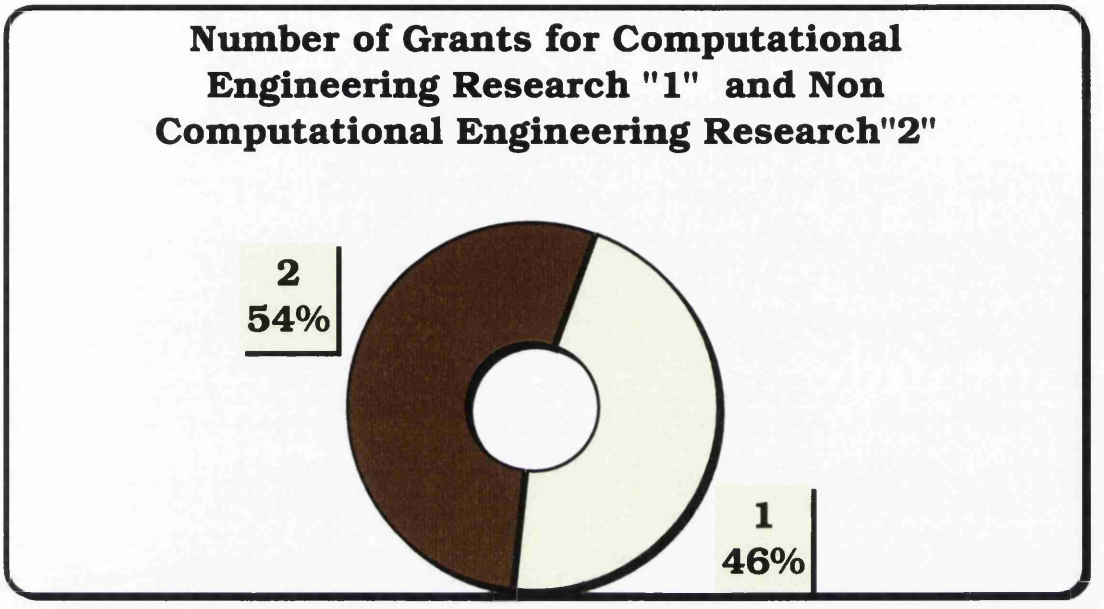
Graph 6

- Graph 7 illustrates that in this program grants for computational engineering, in terms of the value of grants, are around 42% of EPSRC budget for Control and Instrumentation Research in the year 1996.



Graph 7

- A similar situation can be observed on the number of grants. As Graph 8 shows, 46% of the total grants in Control and Instrumentation Program were allocated to computational engineering research.

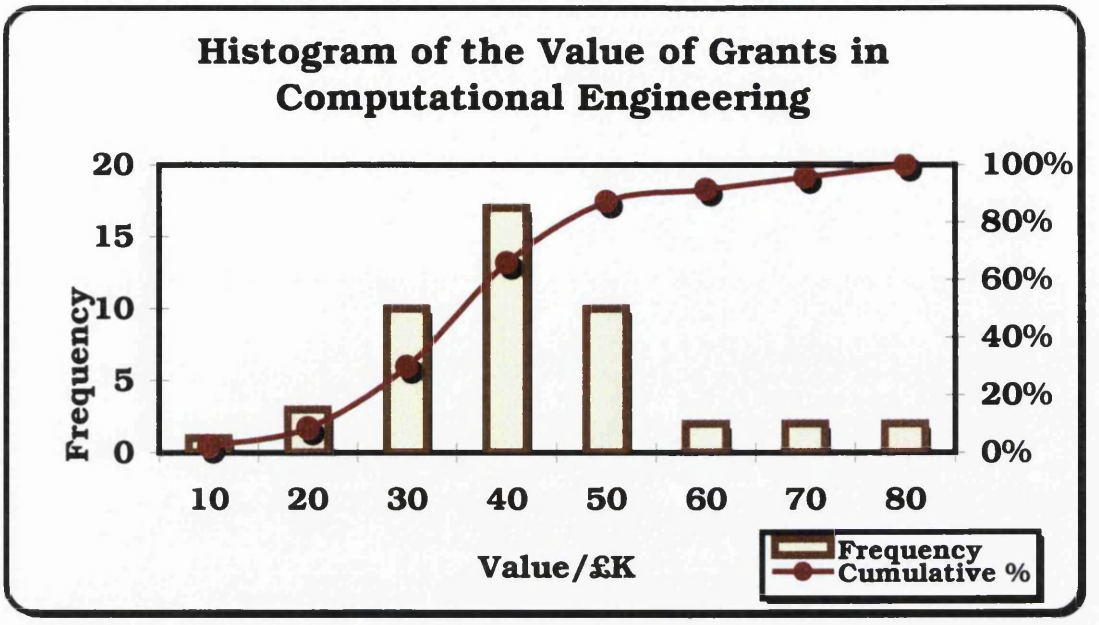


Graph 8

- With the cumulative frequency histogram in Table 5 and Graph 9 it is believed that around 87% of grants involved with computational engineering research are under £60, 000. The histogram in Graph 9 is almost symmetric and almost flat. The small values of kurtosis and skew in Table 4 indicate this too, which would mean the size of grants is rather similar.

Value/ £K	Frequency	Cumulative %
10	1	2%
20	3	9%
30	10	30%
40	17	66%
50	10	87%
60	2	91%
70	2	96%
80	2	100%

Table 5 The Cumulative Frequency Histogram of the Value of Grants in Computational Engineering of Control and Instrumentation Research Programme.

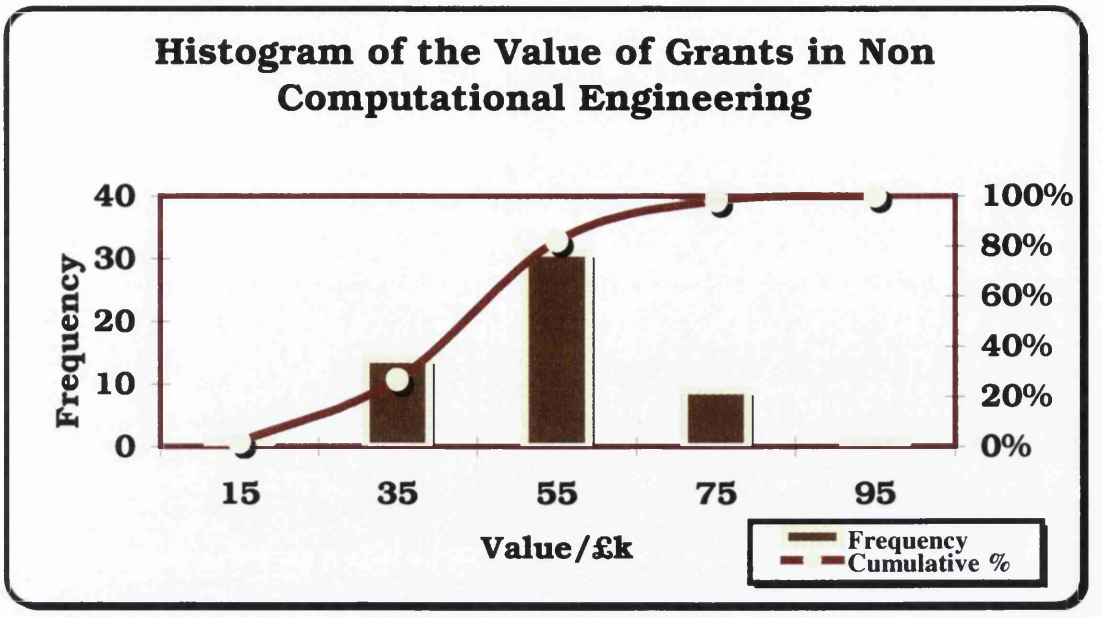


Graph 9

- In Table 6 nearly 98% of the non-computational grants can be up to £75, 000, which indicates that the value of individual grants is higher in this program than the value of grants for computational engineering research. The histogram in Graph 10 is almost symmetric and flat. Again, this indicates the little differences between the value of grants.

Value/ £K	Frequency	Cumulative %
15	1	2%
35	14	27%
55	31	82%
75	9	98%
95	1	100%

Table 6 The Cumulative Frequency Histogram of the Value of Grants in Non-Computational Engineering of Control and Instrumentation Research Programme.



Graph 10

2.7 Design and Integrated Production Research Program 1996

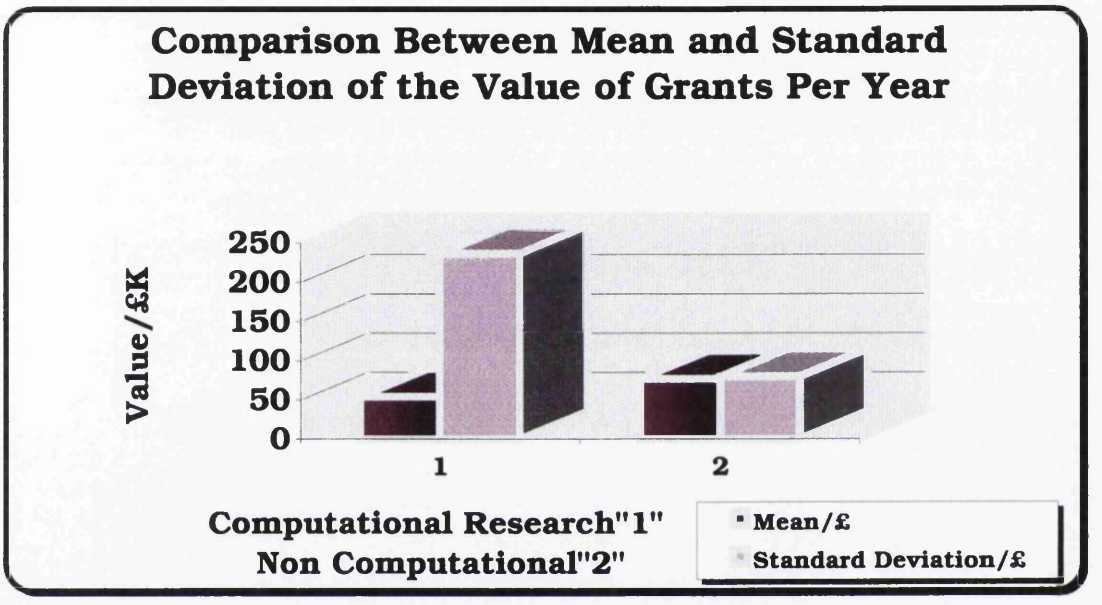
- Descriptive Statistics of computational and non-computational engineering grants for Design and Production Research Program in the year 1996- Appendix3- are shown in Table 7. The contrast seems to be quite sharp according to some of these statistics.

Descriptive Statistics	Computational Research	Non Computational Research
Mean/£	54403	77138
Median/£	54586	56532
Mode/£	#N/A	32605
Standard Deviation/£	23703	79998
Sample Variance	561851715	6399738106
Kurtosis	-0.23	32.1
Skew ness	-0.16	5.1
Range/£	84864	667360
Minimum/£	8308	2640
Maximum/£	93172	670000
Sum/£	870443	12342117
Count	16	160

Table 7 Descriptive Statistics of Computational and Non-Computational Research Grants of the Design and Integrated Production Research Programme 1996

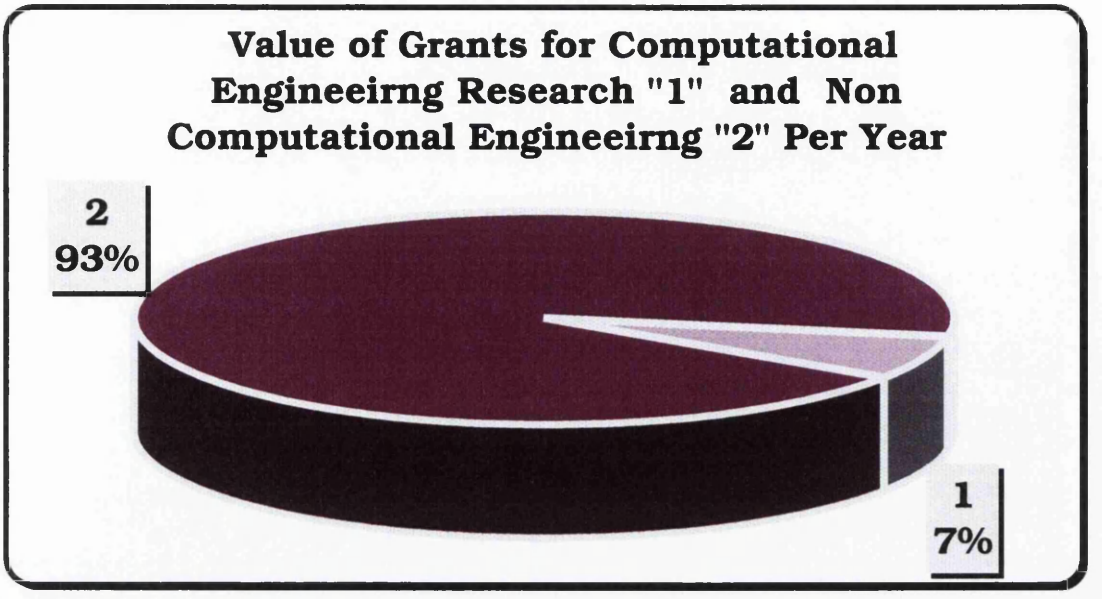
- This program is no exception. The mean of the non-computational engineering grants is far higher than the mean for the computational engineering grants. This would emphasise the fact that non-computational engineering grants are higher than grants related to computational engineering research.

Also, the standard deviation of non-computational is much larger. Thus, the grants are dispersed more widely from the mean; where the large range of non-computational engineering grants indicates this point too.



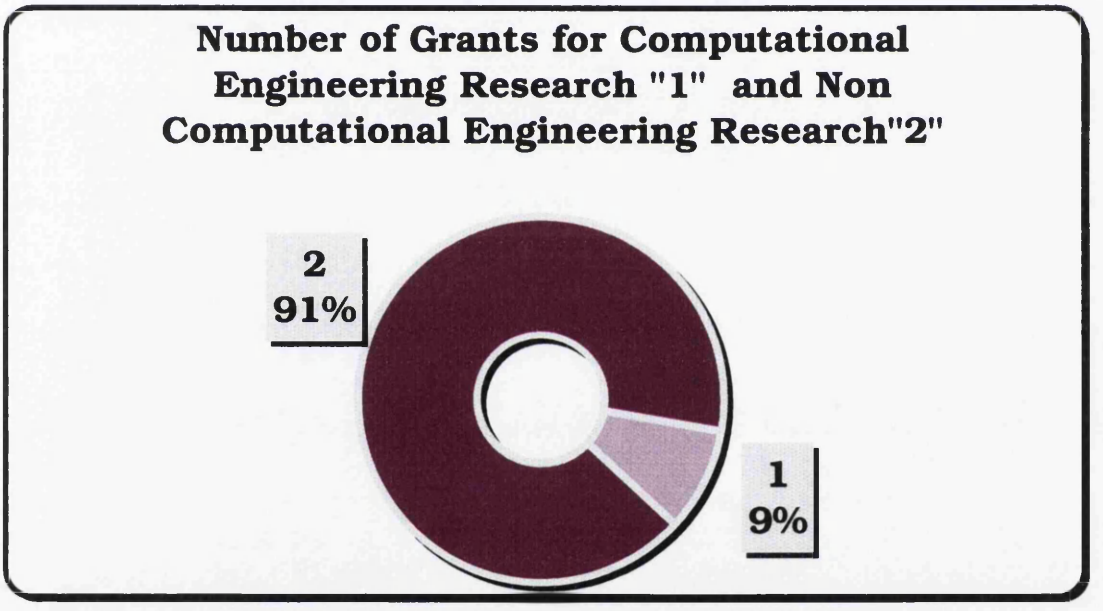
Graph 11

- In the Design and Integrated Production Research Program, 7% of the value of grants was given to computational engineering projects.



Graph 12

- In terms of number of grants, 9% of the total grants allocated by EPSRC to this program were related to computational engineering research.

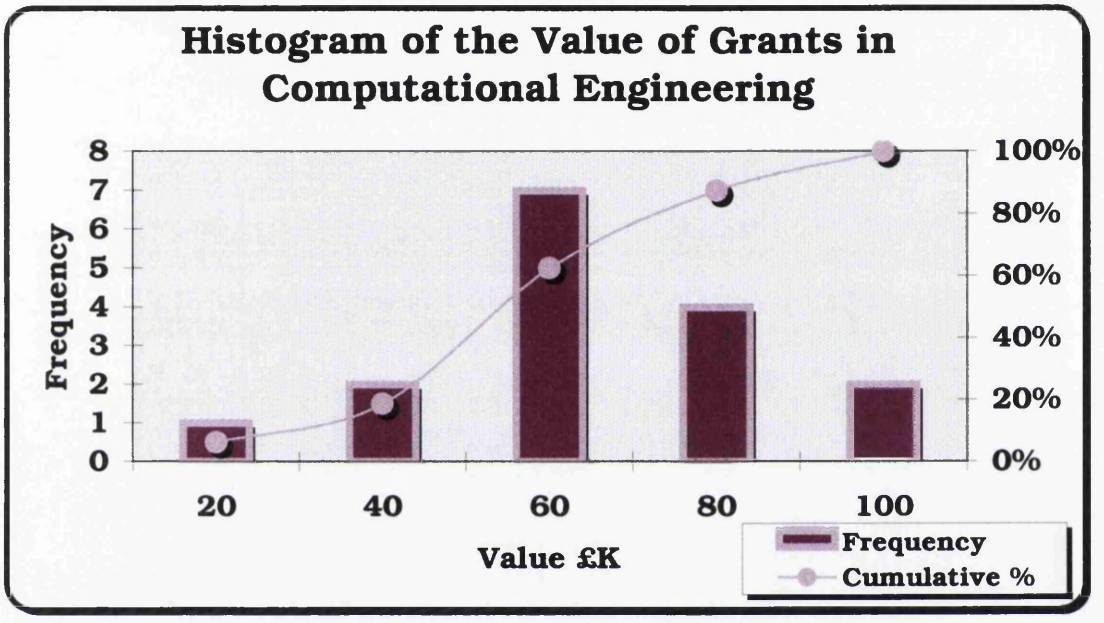


Graph 13

- In Table 8 and Graph 14, it is shown that 88% of the grants have a value that does not exceed £80, 000. Graph 14 shows the frequency histogram nearly symmetric and flat where differences between the values of grants are not very large.

Value/ £K	Frequency	Cumulative %
20	1	6%
40	2	19%
60	7	63%
80	4	88%
100	2	100%

Table 8 The Cumulative Frequency Histogram of the Value of Grants in Computational Engineering of Design and Integrated Production Research Programme.

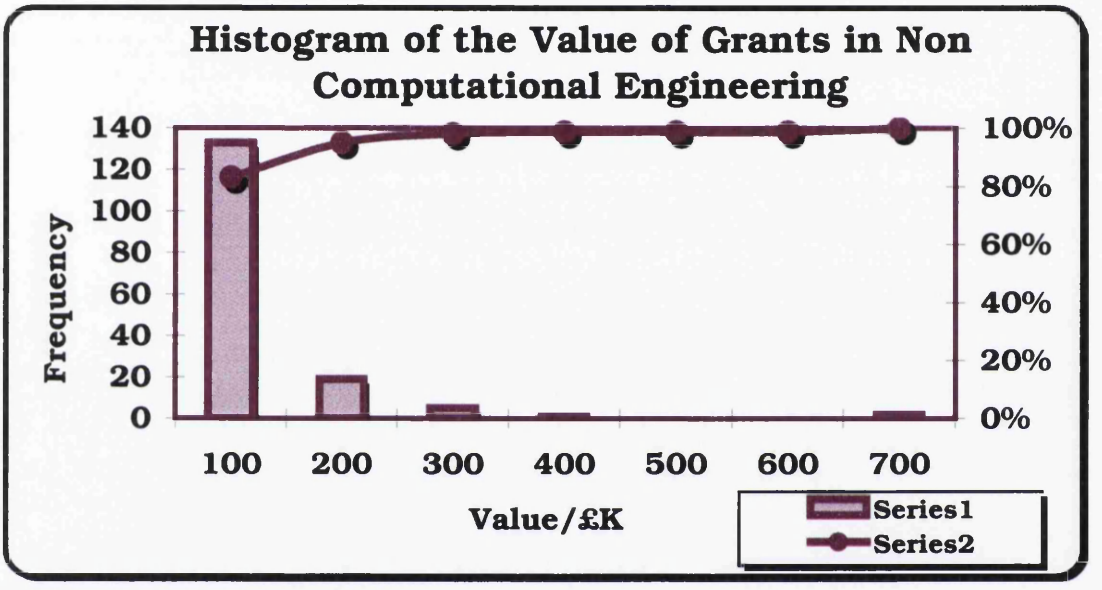


Graph 14

- On the other hand, Graph 15 and Table 9 show that around 98% of the grants related to non-computational research have a value that can reach up to £300, 000. This value is very large compared to computational engineering grants in the previous table and graph. The frequency histogram in graph 15 looks peaked and slightly skewed to the right.

Value/ £K	Frequency	Cumulative %
100	133	83%
200	19	95%
300	5	98%
400	1	99%
500	0	99%
600	0	99%
700	2	100%

Table 9 **The Cumulative Frequency Histogram of the Value of Grants in Non-Computational Engineering of Design and Integrated Production Research Programme.**



Graph 15

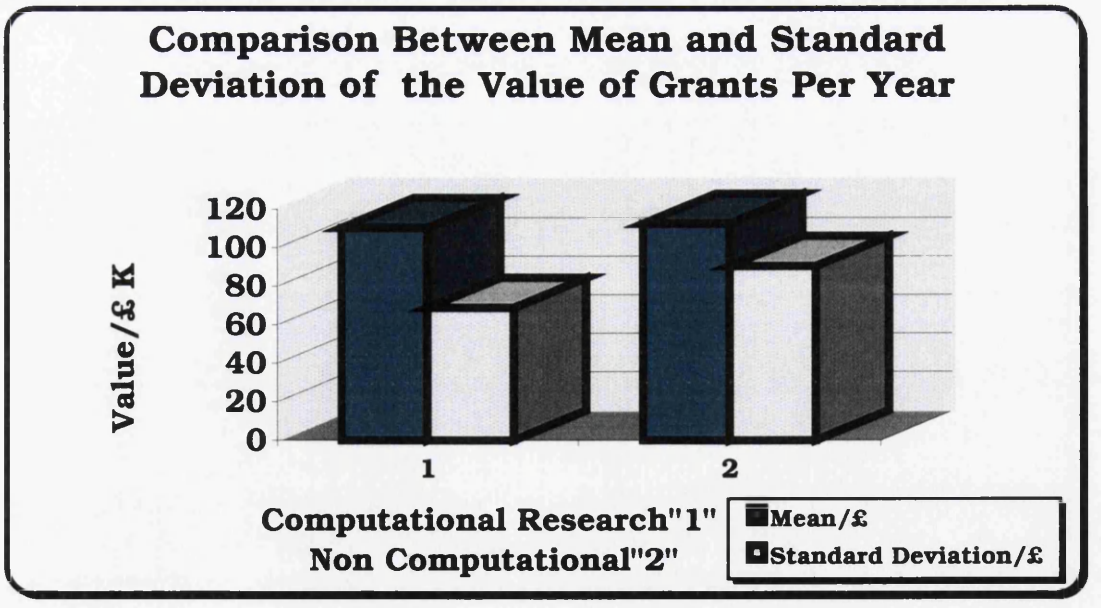
2.8 General Engineering Research Program 1997

- Table 10 shows some of the descriptive statistics of the two sets of computational engineering and non-computational engineering grants for the General Engineering Research Program in the year 1997- see Appendix4. The Following graphs and tables illustrate the difference between both sets of statistics.

Descriptive Statistics	Computational Research	Non Computational Research
Mean/£	110353	112569
Median/£	93559	112102
Mode/£	#N/A	#N/A
Standard Deviation/£	68867	90513
Sample Variance	4742600101	8192627111
Kurtosis	1.0	42.4
Skew ness	0.9	4.7
Range/£	341151	967000
Minimum/£	1992	0
Maximum/£	343143	967000
Sum/£	5959084	20712760
Count	54	184

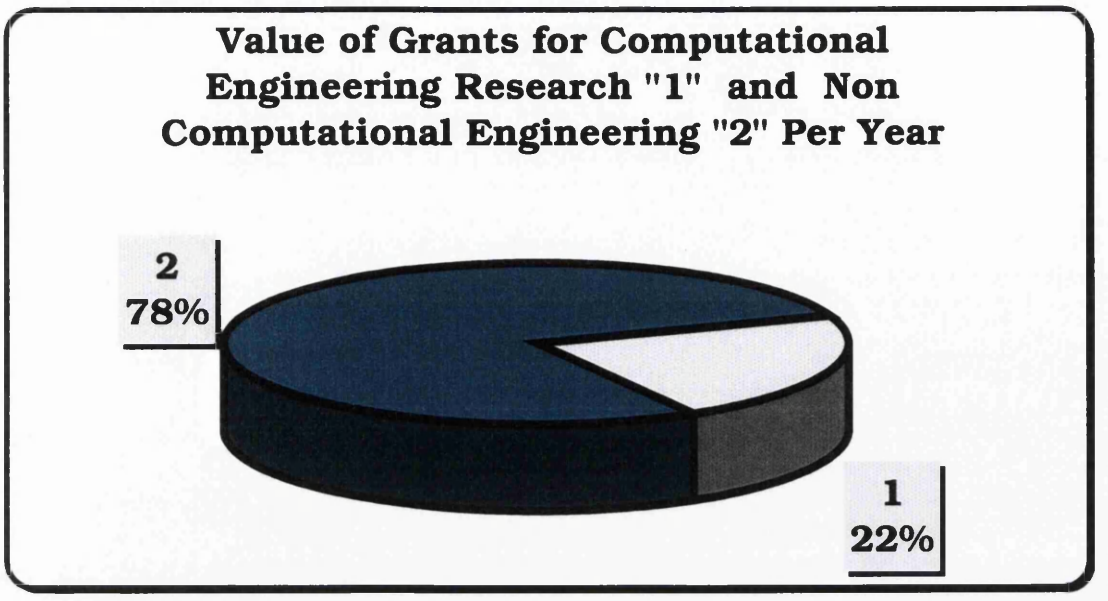
Table 10 Descriptive Statistics of Computational and Non-Computational Research Grants of the General Engineering Research Programme 1996.

- In this programme, the value of the two means is similar. However, since the median for the non-computational engineering is higher the individual value of grants in computational engineering is considerably lower than what it is for other grants. The standard deviation is larger for non-computational grants, which can be due to a large range and a bigger sample.



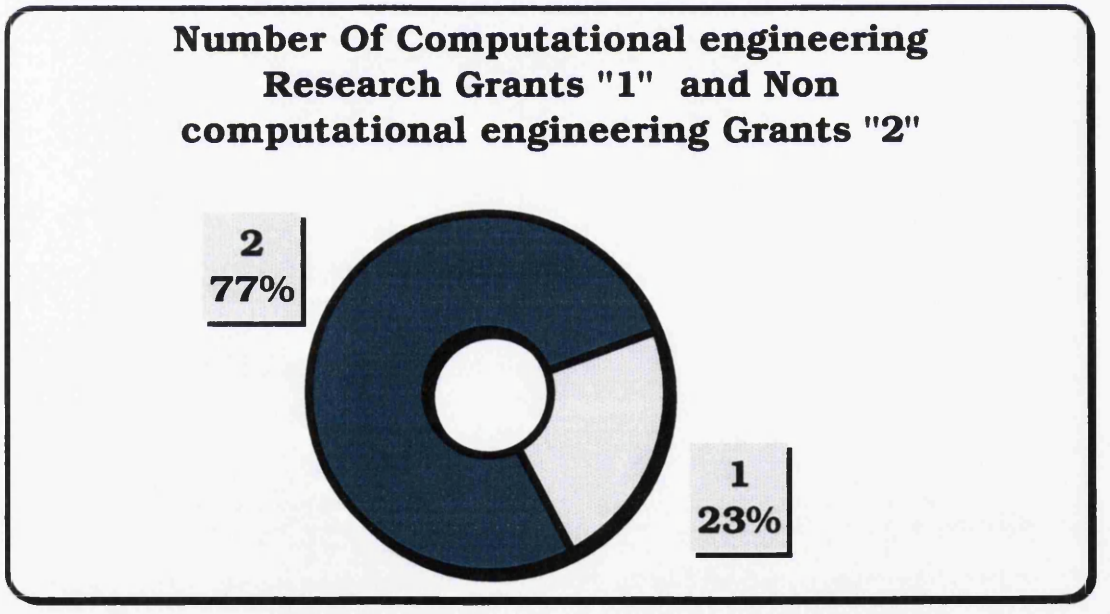
Graph 16

- Graph 17 shows that in this program 22% of the total value of grants are awarded to computational engineering in the year 1997.



Graph 17

- A similar low percentage, that is 23%, of the total number of the grants had been allocated to computational engineering research in the General Engineering Program for the year 1997

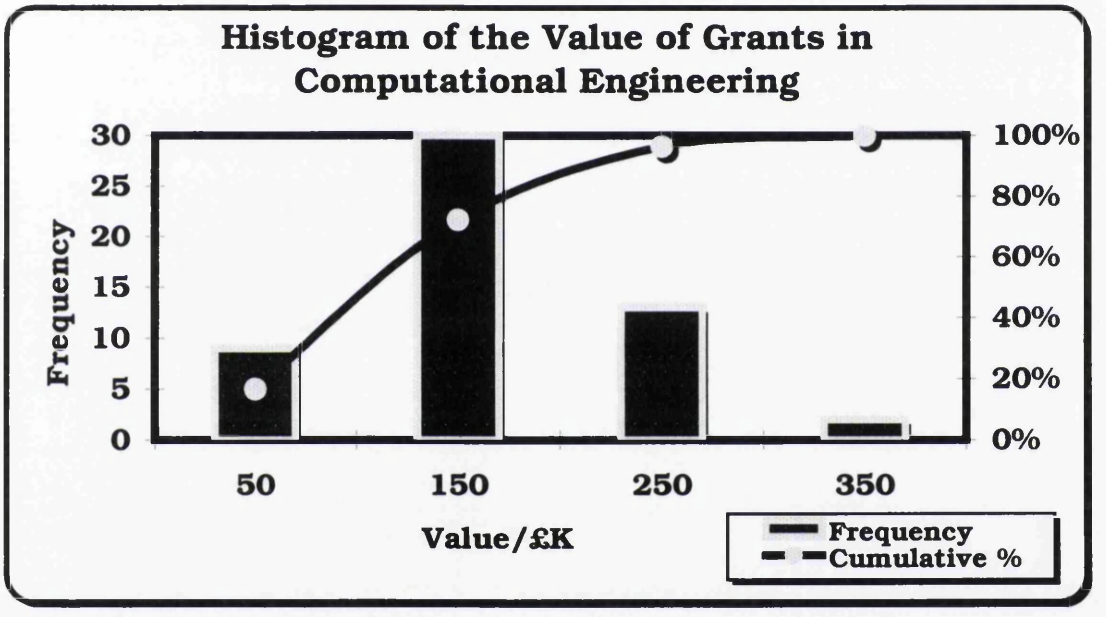


Graph 18

- Table 11 and Graph 19 show the cumulative frequency histogram of computational engineering grants. 96% of the grants are up to £250, 000. The histogram shown in Graph 19 is nearly symmetric. The small values of kurtosis and skew in Table 10 are other indicators for this shape.

Value/ £K	Frequency	Cumulative %
50	9	17%
150	30	72%
250	13	96%
350	2	100%

Table 11 The Cumulative Frequency Histogram of the Value of Grants in Computational Engineering of General Engineering Research Programme.

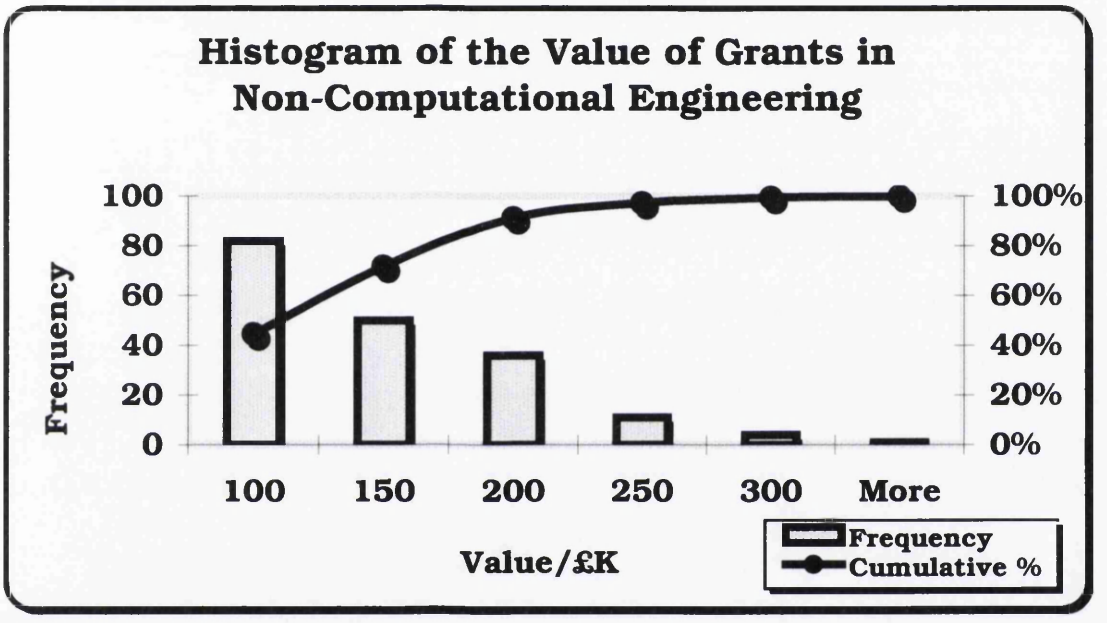


Graph 19

- The cumulative frequency histogram of non-computational engineering grants similarly show that around 97% of the grants are up to £250, 000. The histogram in the Graph 20 is peaked and skewed to the right.

Value/ £K	Frequency	Cumulative %
50	43	23%
100	39	45%
150	50	72%
200	36	91%
250	11	97%
300	4	99%
More	1	100%

Table 12 The Cumulative Frequency Histogram of the Value of Grants in Computational Engineering of General Engineering Research Programme.



Graph 20

2.9 Conclusions

- Computational engineering research in the 1996 Mechanical Engineering Research Program had been funded well by EPSRC. The value of the computational engineering grants was 58% of the total budget.
- For Control and Instrumentation research Program 1996, the funding towards computational engineering research was nearly 42% of the total program funding by EPSRC.
- In Design and Integrated Production Program 1996, the value of grants awarded to computational engineering research was 7% of the total budget.
- Similarly, in 1997, the General Engineering Research Program had 22% of the total value of grants on computational engineering research.
- For all programs, the individual value of grants for computational engineering was shown to be lower than the individual value of grants for non-computational engineering. This reflects on the nature of conducted projects and their potentials.
- However, computational engineering grants had a considerable budget over the period of this study when it came to real terms. In 1996, computational engineering projects were allocated £9 million through all three analyzed programs, while in 1997 projects related to computational engineering had a budget of £6 million.
- EPSRC recognizes the great benefit of computer simulation as an important research area with great potential.

References

[1] The UK Research Councils, Introduction, Role and Mission, About EPSRC, EPSRC, http://www.epsrc.ac.uk/epsrcweb/INDEX.asp, 02/2001

[2] The Foresight Effect, Foresight, http://www.foresight.gov.uk/default1024ns.htm, 02/2001

[3] EPSRC, Mechanical Engineering Programme, Research in Progress 1996

[4] EPSRC, Control and Instrumentation Research 1996

[5] EPSRC, Design and Integrated Production Research 1996

[6] EPSRC, General Engineering Programme, Research Grants Awarded Since 1 April 1997.

[7] C. Chatfield, Statistics for technology a course in applied statistics, Chapman & Hall, 1991, ISBEN 0 412 253402

[8] Microsoft Help

Chapter 3

3.1 Preparing a Questionnaire

To decide the extent of the involvement of Welsh companies with computer simulation, some general and financial information was needed from Welsh companies. Preparing a questionnaire to be sent to a selected sample of these companies was the practical way for gaining this kind of information.

- **What is a Questionnaire?**

A group of researchers, Boyd, Westfall and Stasch have identified in their "Marketing Research" book that "a questionnaire is a list of questions to be asked respondents. Each question is worded exactly as it is to be asked, and the questions are listed in an established sequence. Spaces in which to record answers are provided in questionnaires except in the case of telephone interview. Unfortunately, the problem is deceptive. It is easy to write down questions, but are they the right questions?" [1].

3.2 How to Prepare a Questionnaire

A questionnaire construction is not so much a science as an art, and there is no theory or an established system for questionnaire preparation. It is only general experience that has given some guidelines to researchers.

These rules were listed and explained by the three researchers in "nine steps;

a. Decide what information is wanted.

b. Decide what type of questionnaire (personal interview, mail, telephone) to use.

c. Decide the content of individual questions.

d. Decide on the type of question (open, multiple-choice, dichotomous) to use.

e. Decide on the wording of the questions.

f. Decide on the question sequence.

g. Decide on form, layout, and method of questionnaire reproduction.

h. Make a preliminary draft and pretest it.

i. Revise and prepare the final questionnaire" [1].

a. Decide What Information Is Wanted

Firstly, the goals of the questionnaire should be translated into questions the respondent is willing to answer. Secondly, the questions should provide respondents with a good motivation to give away needed information.

It is very important as well to determine what information is exactly needed so that the anticipated analysis can be made before starting to formulate the questionnaire.

b. Decide the Type of Questionnaire to use

The type of questionnaire is very much dependent on the type of information needed, as well as the type of respondents who are expected to cooperate. Questionnaires can be done in three ways, either by personal interview, or mail or telephone. The decision on the type of questionnaire should be taken at an early stage, as this decision can affect the questions, their formula, and their sequence.

c. Decide the Content of Individual Questions

The next step, is to formulate the questions. It is useful, here, to check the following

Is the question necessary? There are tendencies for including some interesting questions that have no value within a questionnaire. That could cause the average length of the questionnaire to become longer. Extra questions, most probably, would put respondents off completing the questionnaire.

Does the respondent have the information requested? A study made by this group has shown that some respondents will answer confusing questions even if they are not sure what they mean. That's why it is very important to focus on two points; firstly, that information requested is within the respondent's experience. This can be done through an indirect or direct "filter" question to help the respondent find out whether they are involved in the question area or not. Secondly, to consider the ability of the respondent to remember the information requested, as researchers should not rely too much on questions that involve memory. Memory of too many events can be strongly influenced by; how important the event is, how far the individual is able to remember, how long the event goes back, and how the individual's memory is stimulated.

In fact, only the last two factors are within the researchers' affect. It is wise when possible to limit questions to events that have happened at

recent times, and make it easier for respondents to recall the event. This can be done by: **unaided recall**- which is, for instance, presenting the event to respondents instead of asking them to recall without giving clues, or **aided recall-** which is providing a list of answers that includes the actual event taking place at the specified time.

Will the Respondent Have to Do a Lot of Work to Get the Information? When questions need some real work to be done, most respondents will try to guess the reply even if they have access to the information needed. However, few of them will spend time and effort to provide accurate answers if they have a particular interest or think the project will be a good benefit to them. In the case of mail questionnaire, it might simply end up in the wastebasket. Therefore, this kind of questions should be eliminated.

Will Respondents Give Information? Sometimes respondents will not give answers even though they have enough information for that. Two reasons can be behind this: 1) they are not willing to phrase the answers-and in this case helping respondents express what they think can overcome such a problem, by giving them few choices; 2) they do not want to reveal this kind of information.

Are Several Questions Needed Instead of One? Some questions might happen to have two or more elements. Keeping all of them in one question can be very confusing to respondents who will interpret the same question very differently. A "Why" question, for instance, can be most of the time replaced by two questions start with "What" and "How".

d. Decide the Type of Question to Use

Researchers need to decide what type of questions to be used: disguised or non-disguised, structured or non-structured questions. There are three types of questions according to the structure degree:

Open Questions. They are good to start a questionnaire with, as they introduce the subject to respondents to get a general attitude about it, with much less influence on the answers than the other two types. But, they have disadvantages too; the allowance of a large degree of interviewer bias, the big effort and long time they need to sort out format problems, and finally, the implicit importance open questions might give to the upper-class and well educated people who can be far more articulate than some other groups of the population. Even though researchers seem to be in favour of open questions in exploratory research and as a way for getting new ideas, they believe that open and closed questions which are carefully formulated, do obtain almost the same results from data accuracy and data type point of view.

Multiple-Choice Questions. This kind of question provides respondents with certain alternatives where they have to choose their answer.

- These alternatives should be mentioned clearly in the question, or listed at the end.
- "Other" is a very important alternative that should be always provided within the choices, when necessary, so that respondents do not feel like being confused or forced to go for another choice if their answer wasn't included in the list for any reason.
- When multiple-choice questions related to quantities are constructed, overlap between alternatives should be avoided, and most possible choices should be allowed to fall in the middle of categories.
- Multiple-choice questions can bias results by the order given to the alternative answers. More respondents are likely to pick a certain answer when it is first than picking it when it is in a different position. This problem can be avoided by alternating the order of the answers.
- However, it is different when alternatives of multiple-choice questions are numbers. Respondents are likely to select central positions more than they will select either extreme. Providing a category at each end that is more extreme than any respondent would pick, might be a good exit for this problem.

Dichotomous Questions. The principle of this type is to offer two options only to respondents, yes or no, do or do not, etc. It is an extreme case of the multiple-choice question. Dichotomous questions are also called two-way questions.

- As in the multiple-choice questions, it is important that the two alternatives are stated explicitly in the question.
- Their main advantages that they are quick and easy to handle, there is not much editing or tabulating needed and interviewers have less chance to bias the result. The straightforward type of yes-no questions is easy for respondents.
- However, dichotomous questions can be tricky by looking very simple. In fact, some of dichotomous questions are only two-way. Therefore the two possible answers of yes and no are better replaced by five answers: yes, no, probably, probably not, and don't know. It is very likely that unless these alternatives are stated explicitly to the respondents, few people will choose them.
- Sometimes, answers to dichotomous questions can be both alternatives instead of one of them. In this case the "both" category should be yet another alternative.

e. Decide on the Wording of Questions

The following are some important guidelines for question wording. They have been developed by general experience.

Define the Issue. It is essential that all questions do include six points: who, where, when, what, why, and how. The last two points can be suitable for some questions only. These six points should be stated explicitly, without making any wrong assumptions.

Should the Question be Subjective or Objective? Researchers can state most questions in subjective or objective way. For example: -Do you think the Ford car is a better car than the Chevrolet? Is the Ford a better car than a Chevrolet? First question is subjective, while the second is objective. A study that was made to decide which form could obtain better results showed that subjective questions are more likely to give reliable answers, and the choice between these two forms would affect the results.

Positive or Negative Statement. Within a survey, responses are influenced by the use of positive and negative questions. Therefore it is advisable to state them both in every question, or use them alternately.

Use Simple Words. Words in any questionnaire should be chosen carefully, they should have one meaning only. Ordinary words can be very confusing; by either having a list of meanings in the dictionary or by meaning differently to people who come from different parts of the country. The safest way is to stick to simple words so as to create no misunderstanding whatsoever.

Avoid Ambiguous Questions. Ambiguous questions mean different things to different people. Questions should be straightforward with no ambiguous terms such as usually, frequently, normally, and mostly. Alternatively, a specific time should be stated explicitly, like the "last time".

Avoid Leading Questions. Respondents can be asked questions like: How long was the movie? Or how short was the movie? Obviously, these two leading questions will influence respondents' response. Wording of questions can easily push respondents to certain answers.

Do Not Ask Questions in a Way That Will Involve Generalization. As was advised before, questions should ask only about specific times or occasions. When a generalization is required, it can be drawn from the data obtained.

"Cushion" Questions That May Seem Unreasonable to the Respondent. Questions that are personal and private do not normally impress respondents. There should be some introductions that are made to make respondents feel easy about this kind of question.

Use "Split Ballot" Wherever Possible. It is very difficult to decide which wording is wrong, and which wording is right, when having more than one wording to choose from. The best thing to do in this case is to use one on the first half of the questionnaire, and the other on the other half.

f. Decide on Question Sequence

The next step after deciding on the wording of questions is to decide what order they should take. The sequence of Question is important, as results can be affected by it. Normally the body of a questionnaire consists of three main parts:

Basic information, which is the main part of the questionnaire.

Classification information, which is used to help analyse the basic information.

Identification information that can cover respondents and interviewers if necessary.

Opening questions Must Win Respondent's Interest. It is essential to start a questionnaire with an interesting question that attract the attention of the respondent, even if it is not much related to the main subject of the questionnaire. Otherwise, respondents would decide to stop cooperating once they lose interest.

Place Questions Apt to Cause Difficulty in the Body of the Questionnaire. It is recommended to place questions that are not likely to impress respondents, in the body of the questionnaire. After answering a few questions, respondents feel more comfortable answering delicate questions.

Consider the Influence of Questions on Succeeding Questions. Questions that are likely to bias respondents' answers should be left till the end of questionnaire.

Arrange Questions in Logical Order. If questions do not follow a logical order, then respondents will not find it easy to decide about the meaning of the question and its answer.

Mail Questionnaire a Special Problem. Opening questions should attract the respondent's attention, and motivate them to carry on answering the whole questionnaire. But open questions are not the right type to start with a mail questionnaire, as they take lots of writing, and that would put respondents off completing them. Also, leaving questions that are likely to bias respondents' answers to the end, would not apply on mail questionnaires as respondents can always go back to the first questions and modify their answers.

g. Pre code Questionnaire

The obtained data needs to be transferred to the computer for analysis; instead of time consuming tabulation, researchers can precode questionnaires, and enter identified codes to the computer. This will save researchers time, and make them able to think about their questions.

h. Decide on Layout and Reproduction

Physical layout has a great effect on respondents. The next three main points should be considered when deciding the layout and reproduction of a questionnaire:

- **Securing Acceptance of the Questionnaire.** In mail and personal interview surveys, it is important that respondents get attracted to the appearance and design of a questionnaire. General format, spacing, positioning of questions and printing the questionnaire on a good quality paper can all change the attitude of respondents towards completing it.

The name of the sponsor, and the name of the project should be printed clearly at the top of first page or on the cover of the questionnaire.

- **Ease of Control.** If the questionnaires are prepared for interview, then it is sensible to number them serially. This will help keeping a track of all details related to the questionnaire. But numbering questionnaires can't be applied on mail questionnaire, as some respondents will be reluctant to complete it, thinking they are being identified through these numbers. However, questions on mail questionnaire should be numbered serially, to help getting better access to obtained data.
- **Ease of Handling.** When a questionnaire is well reproduced, the whole process becomes smoother. The size of the questionnaire is very important, it should not be too small, if little space is given to respondents' answers, then answers will get crowded, and more errors will happen in obtaining data and conducting analysis. Again if it is printed on too large sheets, a questionnaire can be awkward to handle, especially in interviews. Ideally, around 8×11 inches is the good size.

i. Pre test

It is recommended to pretest questionnaires in field conditions, as no questionnaire is beyond improvement. If major modifications are done following a pretest, then it is wise to do another prtest for the modified questionnaire. Pretests can be done up to 25 times if necessary, but mostly, one pretest is enough. Pretesting normally should focus on the wording of the questions, the question sequence, and the comments and reactions of respondents. As a result, some questions can be eliminated; others can be added.

j. Revision and Final Draft

When no more revisions are suggested in the last pretest, a researcher is ready to print out the final version of the questionnaire and start the fieldwork [1].

3.3 Deciding the Questionnaire Formula

The first stage of preparing and developing the questionnaire was going through all the nine steps. The second stage was following these steps, and deciding what is required from the research.

a. Decide What Information Is Needed.

In the research reported here the questionnaire objective, was to find out how far Welsh companies are involved with computer simulation. To be able to judge this, it was important to get as much data as possible, without putting respondents off filling in the questionnaire, by asking difficult questions. Information needed covered these points:

- Awareness of computer simulation.
- An estimate of the company's financial turnover, and gross profits, in general and when related to computer simulation.
- In addition, an estimate of expenditure of the company on Software and hardware, in general and when related to computer simulation.
- An estimate of the number of employees of the company, and the employees working on computer simulation.
- An estimate of percentage of external and internal R&D budget in general and when related to computer simulation. Also an estimate of total R&D budget.
- Purchasing and selling of software related to computer simulation over the last three years.
- The Company's provision of software related to computer simulation over the last three years.
- The view of computer simulation within the company.
- Company's investment plans in computer simulation for next year.

b. Decide the Type of Questionnaire to use.

The type of information needed was more suitable for a mail questionnaire, with all figures and percentage included within the questions. Taking into account the large number of companies scattered in North and South Wales made it only possible for a mail questionnaire to do the job.

c. Decide the Content of Individual Questions.

Only necessary questions were included. The filter question that asked whether respondents are aware of computer simulation for engineering problems was there to make sure that requested information is within respondents' experience. For the same reason, questionnaires were addressed to the companies' managers or financial directors.

Questions covered up to the last four years. They did not involve much work to answer as they all provided categories to be selected, which was an aided recall, and a good stimulus for respondents' memory. Also, the questions were meant to cover several aspects of the financial profile of a company.

d. Decide the Type of Questions to Use.

Open questions were completely avoided, as it was not desirable to make the questionnaire look as if it needed lots of writing, besides the type of requested data did not allow that. Questions from 2 to 5 were all multiple-choice questions where all alternatives were listed at the end of each questions. These alternatives covered every potential answer.

Overlap between alternatives was avoided, and the most common replies expected were designed to fall around the middle category. Categories provided within the answers had two extreme values at each end to enable respondents reporting their actual value without feeling that their data was extreme. The rest of the questions were dichotomous questions, some of them in their first part only. An answer of yes or no was expected, but the two alternatives were not explicitly stated in the questions because they were found rather confusing. When needed the two answers of yes or no were replaced by five answers of yes, no, probably yes, probably no, and don't know. In the second part of these questions it was the multiple choice questions type again.

e. Decide on Wording the Questionnaire.

The issue of each question was defined properly. Questions 6 to 10 were rather subjective when there was a need for such a formula. Simple and straightforward words were used in the questions as much as possible where ambiguous terms have been avoided. There was no leading questions or generalization. The last question which was expected to irritate respondents when asked if the company is prepared to invest more in computer simulation this year. This question was introduced by another question that asked how computer simulation was viewed in the company.

f. Decide on Questions Sequence.

The basic information in the questionnaire did include classification information about the size of the companies from the turnover point of view, the performance presented by their gross profits, number of employees, R&D budget. Identification information was not essential, it was left up to respondents to reveal their identity, when they were interested in more information about computer simulation (question1) or when they were happy about giving further information (last page's note).

Because Question 5 was expected to have little interest for respondents, it was placed in the middle of the questionnaire. The order of all the 10 questions was decided according to the type of data needed so there were two sets of questions; first set included the numerical data questions, and the second set included the theoretical questions. Presumably, that helped respondents to follow the questions easily. The opening question was a filter question that was meant to help respondents decide at the very early point whether they should take part and fill the questionnaire in or not.

g. Pre code Questionnaires.

There was no need for this, as the sample after all did not exceed 1000 questionnaire. This kind of technique can be useful for big marketing surveys where a huge number of respondents are likely to be involved.

h. Decide on Layout and Reproduction.

A lot of attention was given to the questionnaire's format, with enough spaces provided for answers. It was headed by:

UNIVERSITY OF WALES SWANSEA, CIVIL ENGINEERING DEPARTMENT

The subject of the survey was situated in the middle on the cover of the questionnaire, followed by a note explaining who can be involved with it. Then there was the name of the sponsor with other details. At the end, a note about the Department of Civil Engineering being rated as 5* in research and 'Excellent' in teaching was included. Besides that, the questionnaire was printed on a good quality of A4 papers, which supposedly helped make it look good.

i. Pre test.

There was some kind of a pre test for the questionnaire, which was not exactly meant to be a pre test. After the first sample was sent to 100 companies and according to the returned questionnaire's first analysis there were minor modifications on the questionnaire.

j. Revision and Final Draft.

After the questionnaire was modified, there were no more suggested revisions. The questionnaire was ready to be printed and posted. Yet, one thing was missing, the database of 900 companies.

3.4 Overview of the Questionnaire

The aim of this questionnaire was to obtain some guiding figures from Welsh companies that would indicate their involvement with computer simulation. It consisted of 10 questions

Question 1 - Are you aware of computer simulation?

Question 2 - Asked about issues related to the turnover of the company, including the turnover related to computer simulation (in millions), gross profits and gross profits related to computer simulation (as a percentage of turnover). The answer could be chosen from 7 categories.

Question 3 - Concerned the expenditure of the company on software & maintenance, on hardware & maintenance, expenditure on software & maintenance related to computational simulation and on hardware & maintenance related to computational simulation (as a percentage of turnover). The answer could be chosen from 7 categories.

Question 4 - Asked for the number of employees and number employed on computer simulation. The answer could be chosen from 7 categories.

Question 5- Asked about internal R&D budgets, internal R&D budget for computer simulation, external R&D budget, and external R&D budget for computer simulation. In addition, the total R&D budget (internal & external) and total R&D for computer simulation (internal & external) were sought. The answer could be chosen from 8 categories.

Then there were another 5 theoretical questions

-Had the company purchased any computer simulation software in the last three years?

- Had the company sold any computer simulation software in the last three years?
- Who did the company depend upon for their provision of computational simulation?
- How did the company view computational simulation?
- Was the company prepared to invest more in computational simulation in the current year?

3.5 Companies' Database Collection

Searching for database of hundreds of Welsh companies was not as easy as it was first thought.

3.5.1 WDA Directory of Welsh Companies

The 88 companies' database for the first sample, July 1998, was provided by the WDA through their free copies of two main directories,

- **Interlab Wales** A Directory of Contract Research, Analytical, Testing and Technical Support Services, published 1997
- **Environment Wales** A directory of Goods & Services, published 1998

The two directories included well-detailed information about 540 Welsh companies.

- The name of company
- Its address
- Contact name, and position
- Telephone number, fax, email, and web site of company
- Number of employees
- Organization type
- Main interest
- Main activities
- Areas of expertise
- Target sector

According to the available information, 88 companies were thought to have a potential involvement with computer simulation. Therefore, a copy of the prepared questionnaire was sent to each company. The difficulty only appeared when the questionnaire was finally modified and the addresses of several hundred other suitable companies was requested. By asking the WDA contact officer for more business directories, two other directories, which did not relate to the research area, were provided accompanied with a note to confirm there were no other directories available for public use. At this point, the help desk advice in the University main library was quite useful as it clarified the fact that such a huge database could be only offered by specialised companies and for sale. Given some web site addresses by the help desk, a search for the most suitable offer began, and some interesting information appeared on the D&B Company's web site.

3.5.2 D&B Market Place UK Product

Dun & Bradstreet is a successful company with 160 years of experience. It was said to be "the trusted global source for business information that powers commerce. More

than 100,000 companies rely on D&B to help provide the insight they need to build profitable, quality business relationships with their customers, suppliers, and business partners"[2].

Out of few other products, D&B MarketPlace UK CD-ROM was found to be the most suitable source of information needed. As it contains business information on over 1.6 million UK businesses, to enable users to

- Identify and analyse new markets
- Create telemarketing records
- Create targeted mailing lists
- Generate sample data for market research [2].

The last two options were of concern to this research work and were used to get the second and third samples with their mailing lists ready for post. The earlier stage was selecting businesses, first by line of business, and with a potential involvement with computer simulation, and, secondly, by their geographical location. Initially the second sample of 368 companies, February 1999, was for companies situated in Southern Wales. Later with the third sample the final 544 questionnaires, June 1999, were sent to companies situated in North Wales. Selecting businesses through D&B MarketPlace UK was possible as well by size of business and named executive.

3.6 Line of Business Distribution of 1000 Questionnaires

The following four businesses were chosen as potential engineering areas involved with computer simulation. The percentage of each line of business is shown as well. D&B Market Place did not provide the same kind of details about each company's business. However, all effort was made to get the right choice of companies, in order to get a good percentage of reply.

1000 Questionnaires
1000 Companies
With 60 Line of Businesses

Engineering and Architectural Services
27%

Industrial Machinery & Equipment
19%

Computer Programming & Software
18%

Chemicals and allied Products
0.06%

3.7 Conclusions

- The best construction of a questionnaire is the one that can capture a respondent's attention and get them to comfortably reveal as much information as possible.
- The questionnaire, consisted of one general question that covered awareness of computer simulation, then a set of four questions that requested figures related to turnover, profits, expenditure on hardware & software, number of employees, and R&D budget. The third part was another set of five questions that covered how computer simulation is viewed by Welsh Companies- see Appendix5.
- WDA directories for Welsh companies' database had some details about the business of each company, and also helped filtering all addresses of companies involved with computer simulation.
- Large databases can be obtained from companies that are specialized in selling the most reliable and up to date data. D&B is one of them, and its product D&B Market Place was very interesting and a useful source of information.
- Using D&B Market Place CD-ROM, the line of business was chosen carefully in order to get as many companies as possible that may be involved with computer simulation.

References

[1] Marketing Research, Text and Cases, Seventh Edition, Harper W. Boyd, Jr., Ralph Weslfall, Stanley F. Stasch, 1984.

[2] Company Profile, About D & B, Dun & Bradstreet, http://www.dnb.com/dbproducts/0,1580,2-222-1019-0,00.html, 01/2001.

Chapter 4

4.1 Relationship between a Company's Involvement with Computer Simulation and their Geographical Situation

4.1.1 Geographical Distribution of 1000 questionnaires Sent to South and North Wales

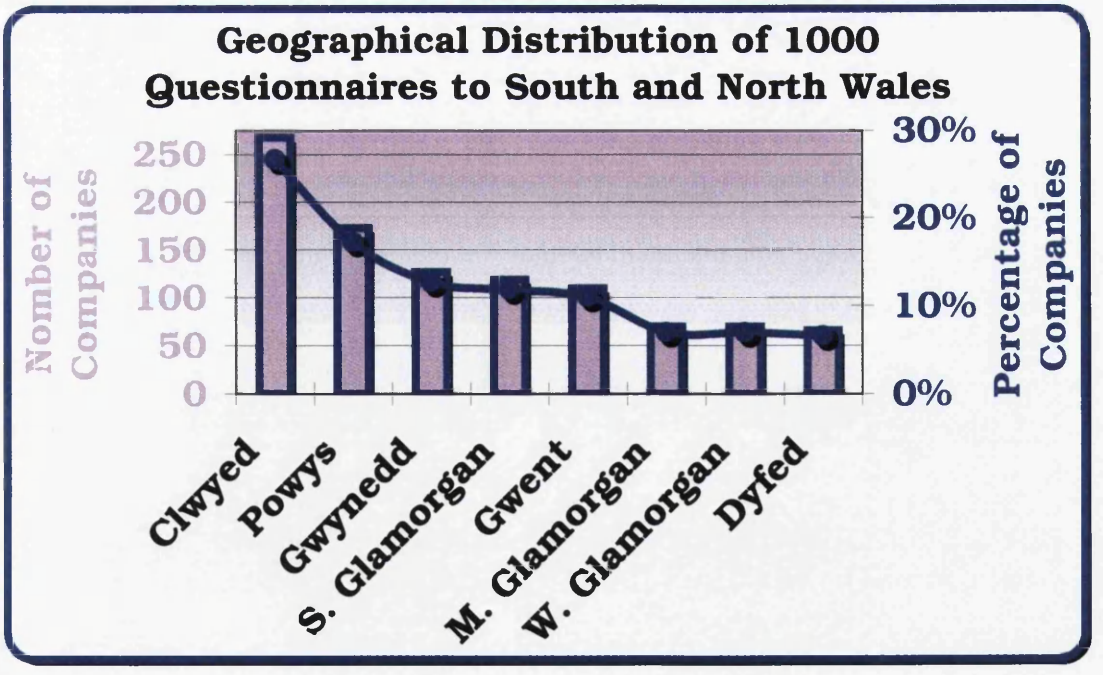
A company was chosen regardless of their geographical situation. A profile about these companies' geographical data was kept to show that all Welsh counties were covered in a proper way and none of them was excluded. So, the 1000 questionnaires were sent to

- 435 companies in South Wales, with the following geographical distribution
  - **a.** South Glamorgan 119
  - **b.** Gwent 110
  - **c.** Mid Glamorgan 70
  - **d.** West Glamorgan 70
  - **e.** Dyfed 66
- 565 companies in North Wales with the following geographical distribution:
  - **a.** Clwyed 267
  - **b.** Powys 172
  - **c.** Gwynedd 126

This is also illustrated in Table 4.1 and Graph 4.2 where the geographical distribution of the questionnaires in Welsh Counties is showed as an actual quantity and as a percentage.

County	Number of Companies	Percentage of Companies
Clwyed	267	27%
Powys	172	17%
Gwynedd	126	13%
S. Glamorgan	119	12%
Gwent	110	11%
M. Glamorgan	70	7%
W. Glamorgan	70	7%
Dyfed	66	6%
Total	1000	100%

Table 4.1 Geographical Distribution of 1000 Questionnaires to South and North Wales



Graph 4.1

4.1.2 Geographical Distribution of the Returned Questionnaires

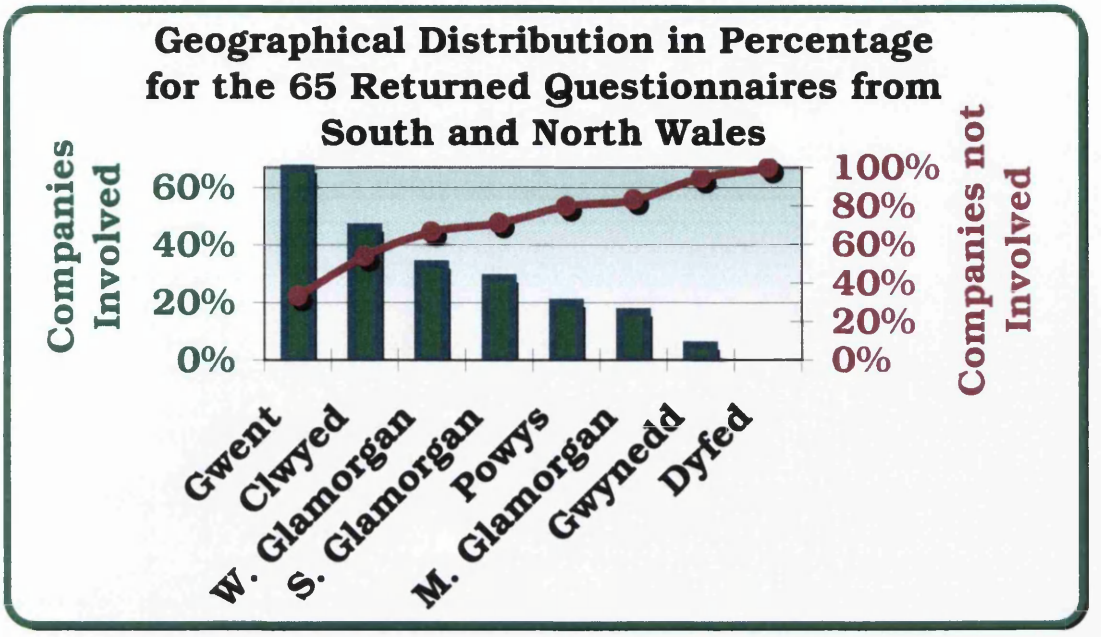
150 companies responded by filling in the questionnaire and posting it back to the address provided. Within this sample, it was found that:

- 65 companies revealed both data and their involvement with computer simulation (Graph 4.2)
- Another 63 companies gave information about their involvement with computer simulation, but there was no further information. This gives a total of 128 companies with information about being involved or not involved with computer simulation
- Only 24 companies, out of 128 companies, indicated they were involved with computer simulation.
- Again, 75 companies provided proper data by filling in most of the questions and giving explicit answers.
- However, companies that went under Can't Decide category were the 22 companies that did not reveal any kind of useful information.

Table 4.2 shows these figures. Gwent had the lead with 67%, out of six companies, involved with computer simulation. None of the three responses from Dyfed stated that they had any involvement with computer simulation, that is 100%, the highest percentage, for no involvement between all counties.

County	Companies involved	%	Companies not involved	%	Can't Decide	Total
Gwent	4	67%	2	33%		6
Clwyed	6	46%	7	54%		13
W. Glamorgan	2	33%	4	67%		6
S. Glamorgan	2	29%	5	71%		7
Powys	1	20%	4	80%		5
M. Glamorgan	1	17%	5	83%		6
Gwynedd	1	5%	18	95%		19
Dyfed	0	0%	3	100%		3
Sub Total	17	26%	48	74%		65
No known address	7	11%	56	89%		63
Can't Decide						22
Total	24	16%	104	69%	22	150

Table 4.2 Geographical Distribution in Percentage for the 65 Returned Questionnaires form South and North Wales



Graph 4.2

4.2 Comparison between Total R&D Budget and R&D on Computer Simulation

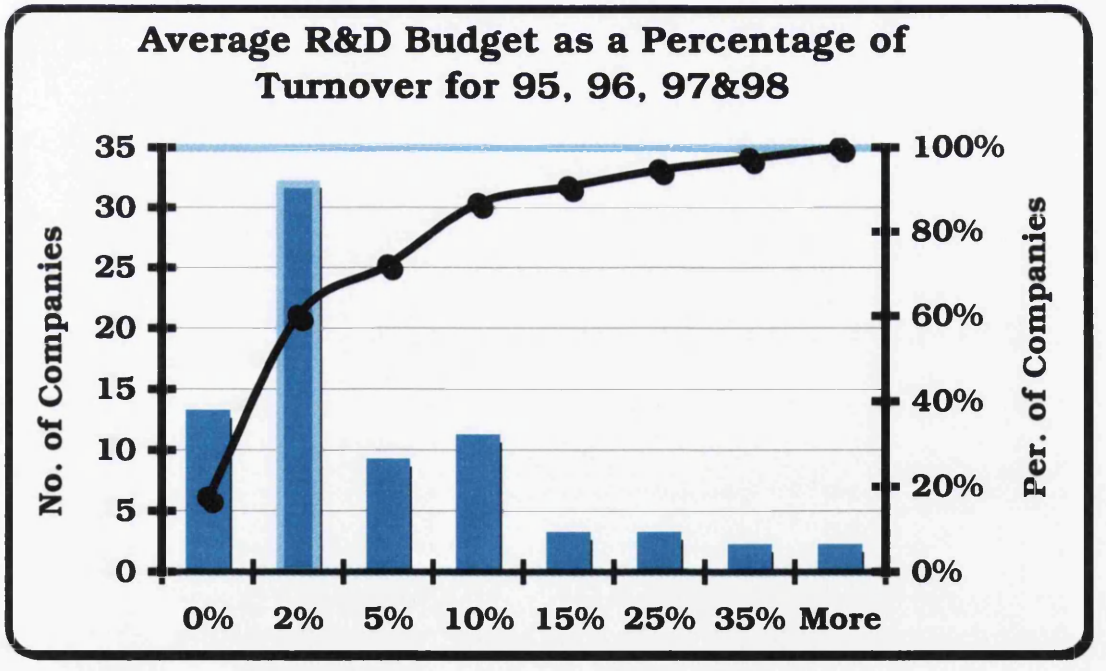
As was mentioned before, 75 of the companies that responded did provide almost full answers. The data that covered the R&D budget as a total, and R&D budget spent on computer simulation was obtained as a percentage of a companies' turnover. Now a general comparison between the two budgets was done, and the following points were found:

- Nearly 17% of this sample did not have an R&D budget in the first place, Table 4.3. However, a much higher percentage, that is 75% of this sample did not have R&D budget for computer simulation, Table 4.4.
- Since companies with no R&D budget should be excluded, then the average spending of 69% of companies (52/62) on R&D budget would be nearly 3.7% of their turnover.
- A similar percentage of 74% (14/19) of companies that are involved with computer simulation and had R&D budget on computer simulation, spent an average of 0.015% of their turnover on R&D budget for computer simulation.

Comparing these two percentages, 0.015% and 3.7%, shows how little is spent on R&D budgets for computer simulation. As R&D Budget for computer simulation = 1 / 247 total R&D Budget.

R&D out of Turnover	Frequency	Cumulative %
0%	13	17%
2%	32	60%
5%	9	72%
10%	11	87%
15%	3	91%
25%	3	95%
35%	2	97%
More	2	100%

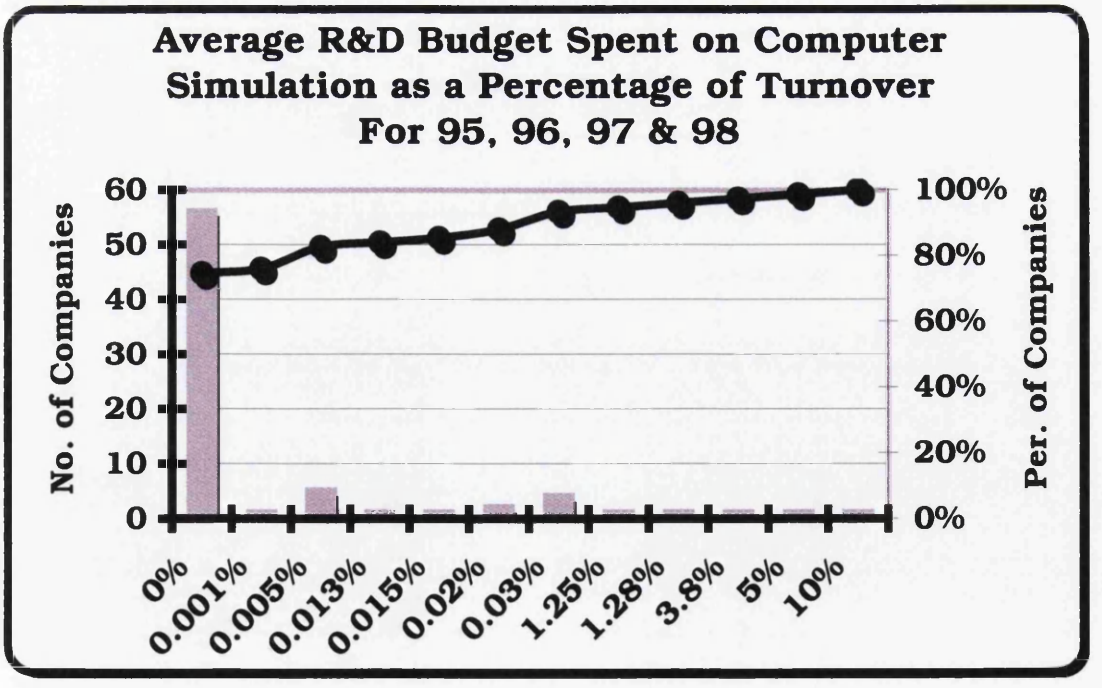
Table 4.3 Average R&D budget as a Percentage of Turnover for 95, 96, 97&98



Graph 4.3

R&D on CS out of Turnover	Frequency	Cumulative %
0.000%	56	75%
0.001%	1	76%
0.005%	5	83%
0.013%	1	84%
0.015%	1	85%
0.02%	2	88%
0.03%	4	93%
1.25%	1	95%
1.28%	1	96%
3.8%	1	97%
5%	1	99%
10%	1	100%

Table 4.4 Average R&D Budget Spent on Computer Simulation as a Percentage of Turnovers for 95, 96, 97&98



Graph 4.4

4.3 Possible Impact of an Increase in Turnover on the R&D Budget for Computer Simulation for the Years 96, 97 & 98

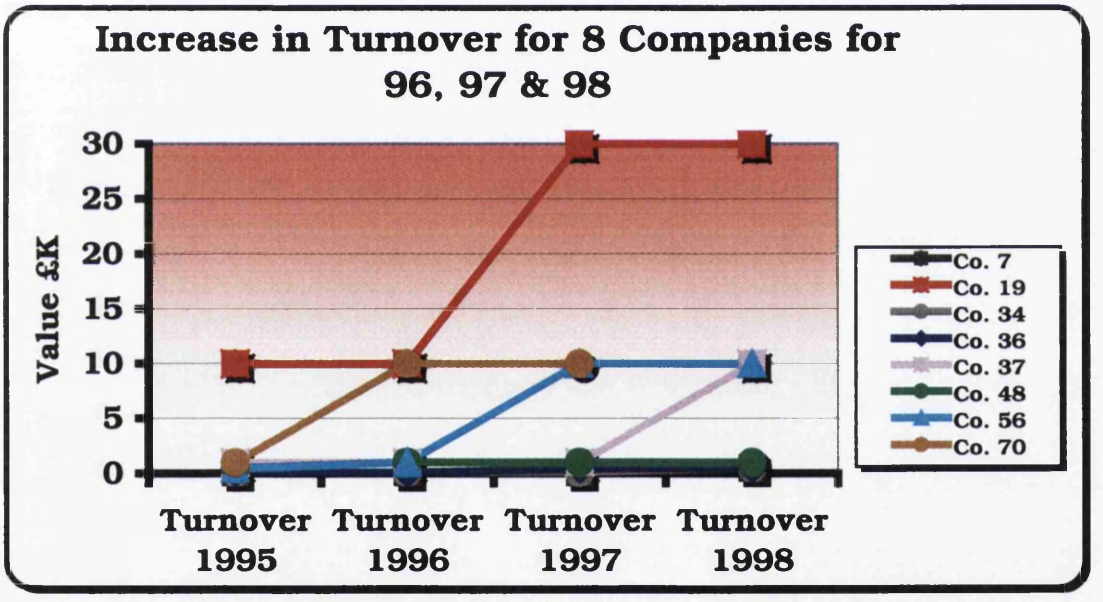
The target of this section is to determine whether an increase in a companies' turnover would have an impact on the R&D budget on computer simulation. It is believed that a successful and expanding company should be more tempted to explore new technologies and improve spending on R&D budget.

The analysis of the available data of 75 companies shows the following points:

- Eight companies- these are N0. 7, 19, 34, 36, 37, 48, 56, 70 increased their turnover within the categories provided in the questionnaire. This is illustrated in Table 4.5 and Graph 4.5.
- In return, the R&D budget for computer simulation as a percentage remained the same for the six companies. The other two had their R&D budget on computer simulation percentage increased as it is showed in Table 4.6, but because of the scale in Graph 4.6, only one of them was shown.
- One positive indication about increasing investment in R&D budget on computer simulation could be the percentage change of it in Table 4.10a and Graph 4.10, where some of these companies doubled their R&D budget up to 9 times at some point.
- However, where an increase in investment in computer simulation was observed, this could be almost by an order of magnitude. As the actual amounts of investment is still numerically very small- Table 4.7b.
- The previous points all suggest that increased turnover in companies did not impact their R&D spending on computer simulation.

Company No.	Turnover 1995/£M	Turnover 1996/£M	Turnover 1997/£M	Turnover 1998/£M
Co. 7	0.1	0.1	0.1	0.5
Co. 19	10	10	30	30
Co. 34	0.1	0.1	0.1	0.5
Co. 36	0.1	0.1	0.5	0.5
Co. 37	1	1	1	10
Co. 48	0.5	1	1	1
Co. 56	0.5	1	10	10
Co. 70	1	10	10	

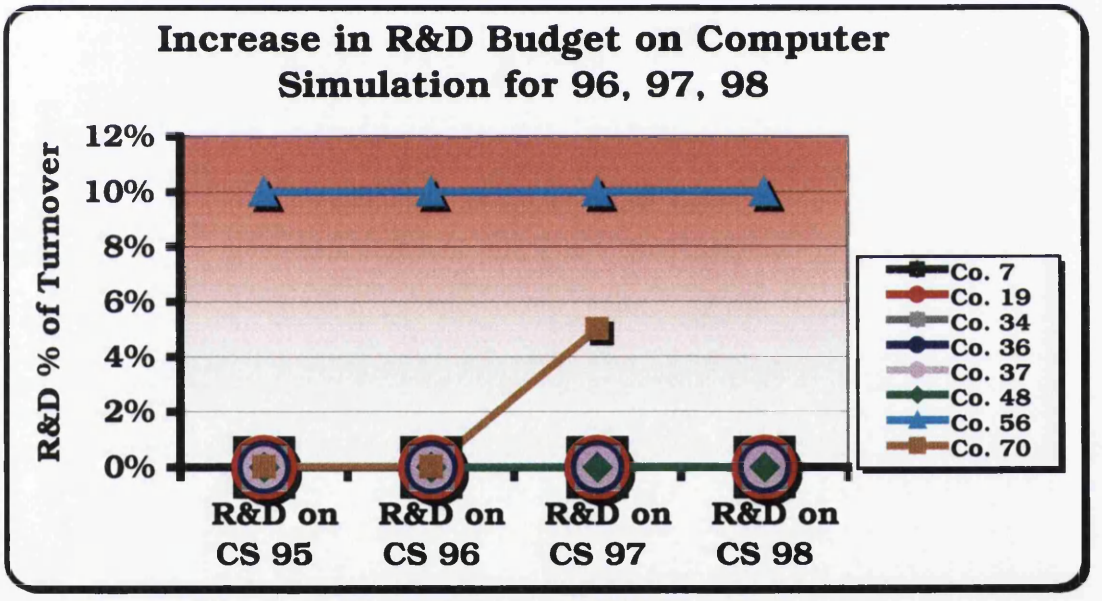
Table 4.5 Increases in Turnover for 8 Companies for 96, 97&98



Graph 4.5

Company No.	CS R&D Budget out of Turnover 1995	CS R&D Budget out of Turnover 1996	CS R&D Budget out of Turnover 1997	CS R&D Budget out of Turnover 1998
Co. 7	0.005%	0.005%	0.005%	0.005%
Co. 19	0.005%	0.005%	0.005%	0.005%
Co. 34	0.005%	0.005%	0.005%	0.005%
Co. 36	0.005%	0.005%	0.005%	0.005%
Co. 37	0.005%	0.005%	0.02%	0.02%
Co. 48	0.005%	0.005%	0.005%	0.005%
Co. 56	10%	10%	10%	10%
Co. 70	0.04%	0.04%	5.02%	

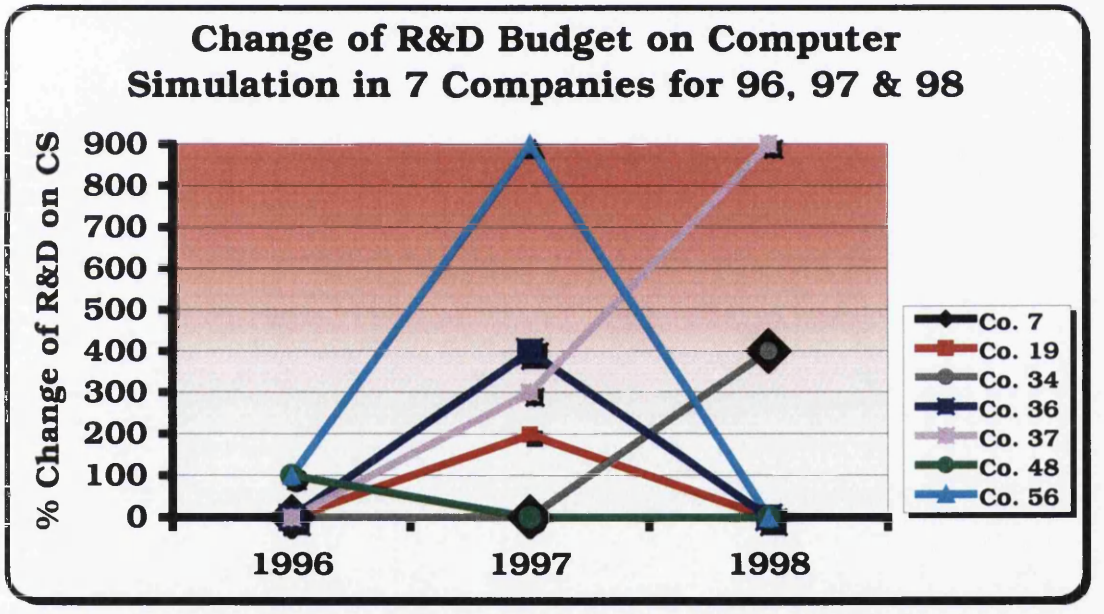
Table 4.6 Increases in R&D Budget on Computer Simulation for 96, 97&98



Graph 4.6

Company No.	% Change of R&D Budget on CS 1996	% Change of R&D Budget on CS 1997	% Change of R&D Budget on CS 1998
Co. 7	0	0	400
Co. 19	0	200	0
Co. 34	0	0	400
Co. 36	0	400	0
Co. 37	0	300	900
Co. 48	100	0	0
Co. 56	100	900	0
Co. 70	900	Excluded*	

Table 4.7a Percentage Change in R&D Budget on Computer Simulation in 8 Companies



Graph 4.7

Company No.	Total R&D "CS" budget £K 1995	Total R&D "CS" budget £K 1996	Total R&D "CS" budget £K 1997	Total R&D "CS" budget £K 1998
Co. 7	0.005	0.005	0.005	0.025
Co. 19	0.5	0.5	1.5	1.5
Co. 34	0.005	0.005	0.005	0.025
Co. 36	0.005	0.005	0.025	0.025
Co. 37	0.05	0.05	0.2	2
Co. 48	0.025	0.05	0.05	0.05
Co. 56	50	100	1000	1000
Co. 70	0.4	4	502	

Table 4.7b Total R&D Budget on Computer Simulation in Real Terms for 8 Companies

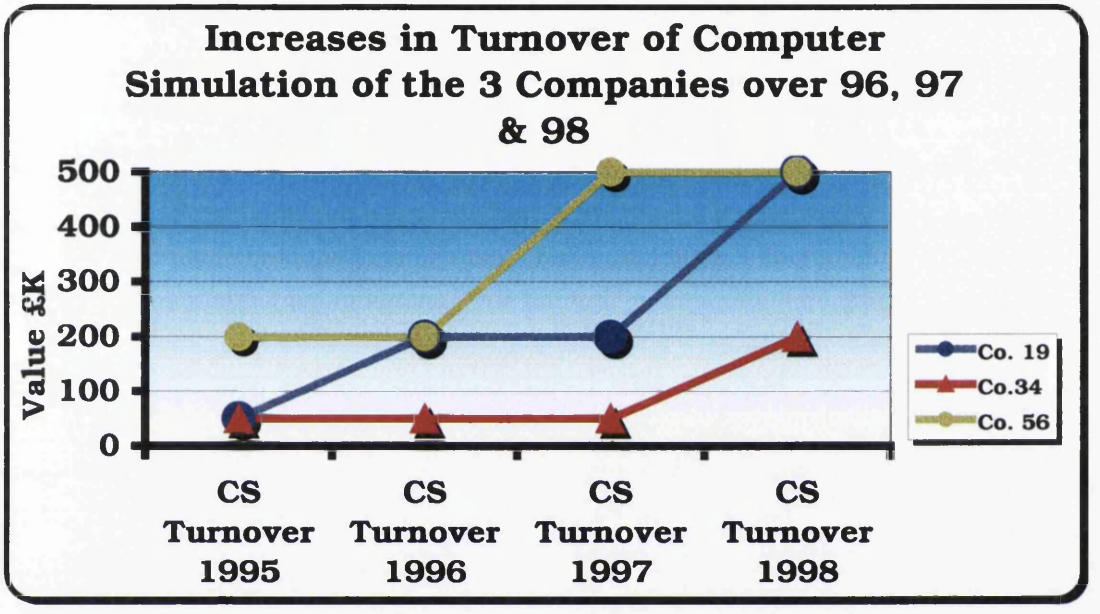
4.4 Possible Impact of an Increase in Turnover for Computer Simulation on the R&D Budget for Computer Simulation for the Years 96, 97 & 98

The next step is about studying the kind of impact that an increased turnover of computer simulation might have on the R&D budget for computer simulation. Again, the analysis of the available data of 75 companies is presented in the following points:

- Three companies- No.19, 34 and 56 had an increased turnover in the area of computer simulation. This is illustrated in Table 4.8 and graph 4.8. The same three companies had also an increase in their turnover which was analyzed in section 4.3.
- However, the percentage of the R&D budget for computer simulation in these three companies remained constant, as it is shown in Table 4.9 and Graph 4.9.
- If the percentage change in the R&D budget on computer simulation, shown in Table 4.10a and Graph 4.10 was considered, then the R&D investments on computer simulation in these three companies were increased by a factor of 9 as is the case for company No. 56.
- Nevertheless, when it came to real terms, these investments were very small. Table 4.10b illustrates this- apart from company 56.
- The previous points suggest that there is little evidence that increase in computer simulation turnover affects R&D budget for computer simulation.

Company No.	Computer Simulation Turnover 1995/£K	Computer Simulation Turnover 1996/£K	Computer Simulation Turnover 1997/£K	Computer Simulation Turnover 1998/£K
Co. 19	50	200	200	500
Co.34	50	50	50	200
Co. 56	200	200	500	500

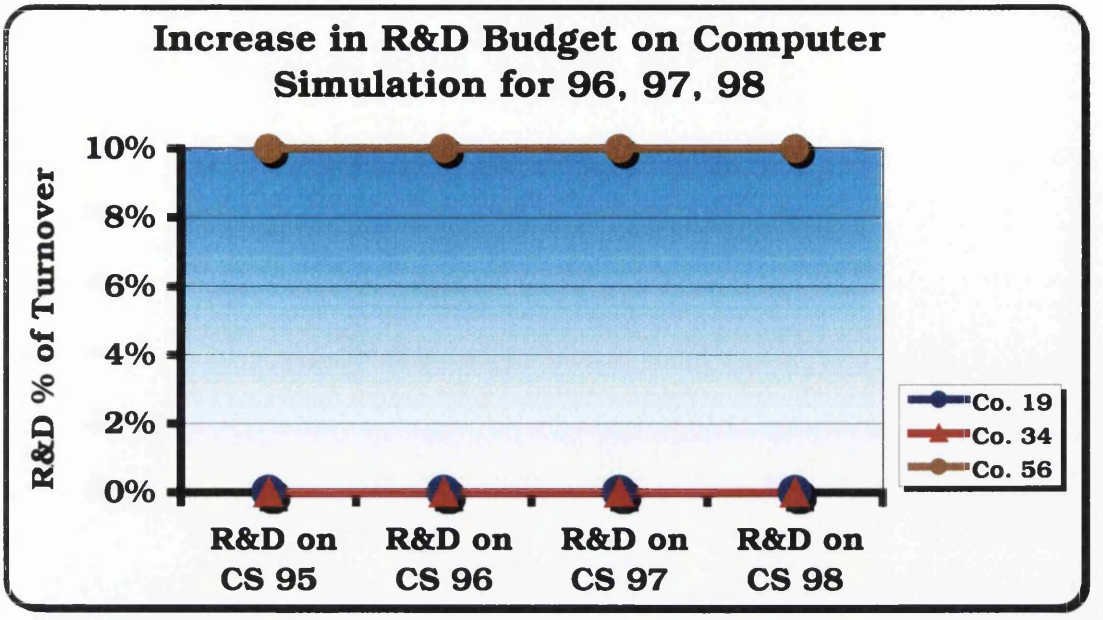
Table 4.8 Increases in Computer Simulation Turnover for 3 Companies for 96, 97&98



Graph 4.8

Company No.	CS R&D Budget % of Turnover 1995	CS R&D Budget % of Turnover 1996	CS R&D Budget % of Turnover 1997	CS R&D Budget % of Turnover 1998
Co. 19	0.005%	0.005%	0.005%	0.005%
Co. 34	0.005%	0.005%	0.005%	0.005%
Co. 56	10%	10%	10%	10%

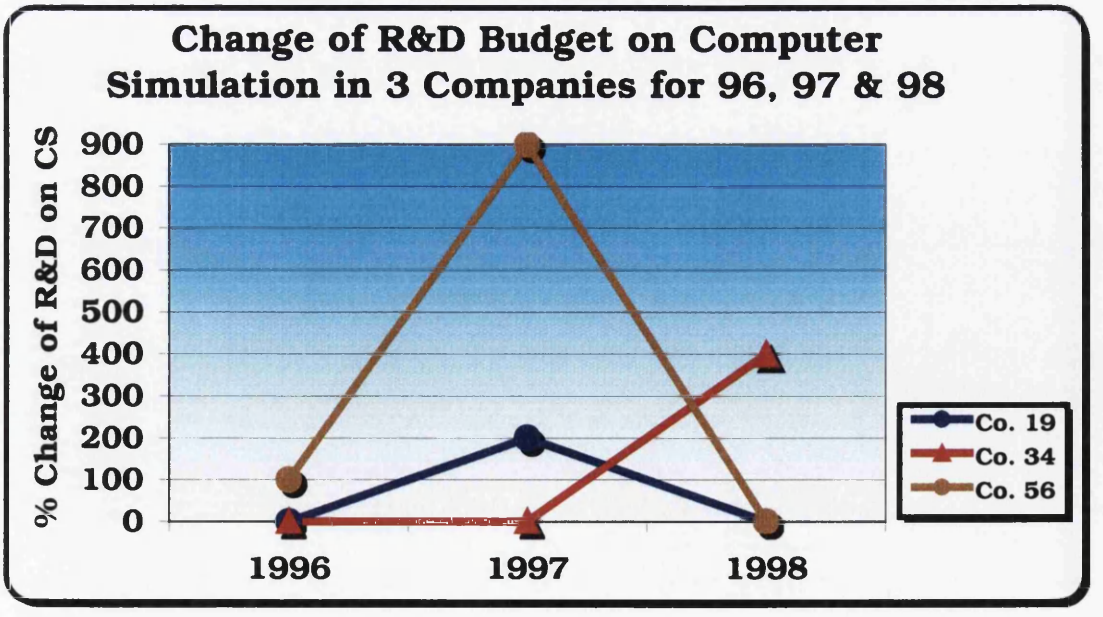
Table 4.9 Increases in R&D Budget on Computer Simulation for 96, 97&98



Graph 4.9

Company No.	% Change of R&D Budget on CS 1996	% Change of R&D Budget on CS 1997	% Change of R&D Budget on CS 1998
Co. 19	0	200	0
Co. 34	0	0	400
Co. 56	100	900	0

Table 4.10a Percentage Change in R&D Budget on Computer Simulation in 3 Companies



Graph 4.10

Company No.	Total R&D "CS" budget £K 1995	Total R&D "CS" budget £K 1996	Total R&D "CS" budget £K 1997	Total R&D "CS" budget £K 1998
Co. 19	0.5	0.5	1.5	1.5
Co. 34	0.005	0.005	0.005	0.025
Co. 56	50	100	1000	1000

Table 4.10b Total R&D Budget on Computer Simulation in Real Terms for 3 Companies

4.5 Companies' Productivity in Computer Simulation

Comparing labour productivity between different companies would involve consideration of the average physical product per employee, which in this case is difficult to assess [1].

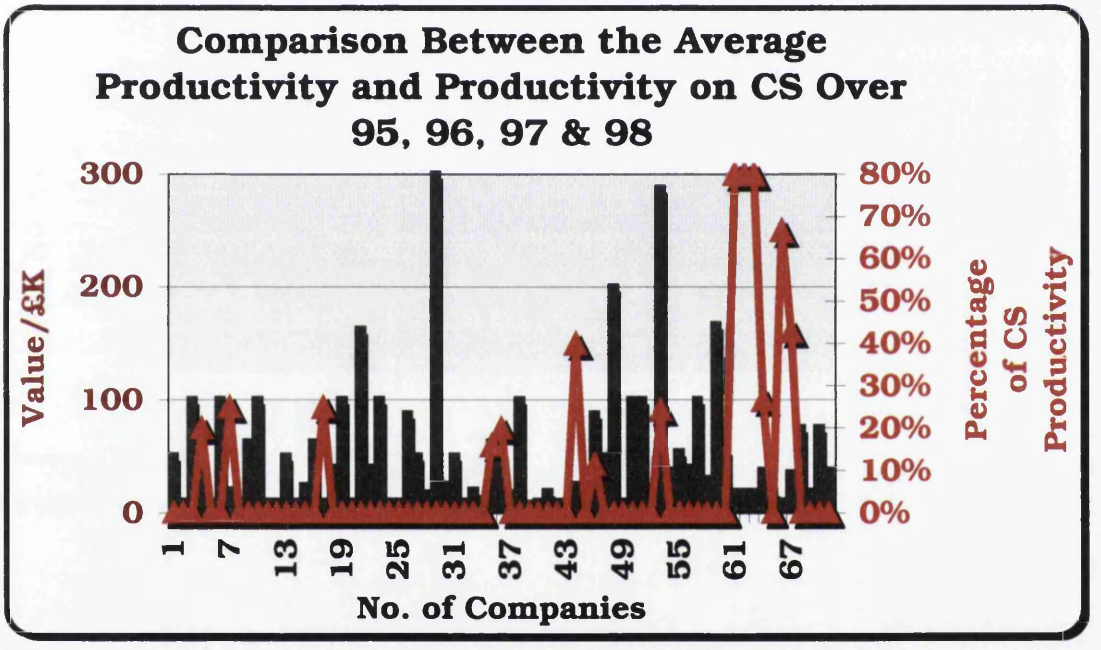
In fact, the amount of information obtained from Welsh companies was very limited, and hence it is difficult to draw general conclusions. The initial target for gaining these figures was to assess the performance of the addressed companies in general and in computer simulation area specifically. Instead of attempting to obtain exact figures or information that could be confidential for many of the companies, the questionnaire provided general categories to be selected.

As a result, Sales per employee- Sales/Number of Employees, was used as an indication for companies' productivity and hence performance. Two assumptions were made towards this; the number of employees presented always the full time employees, and secondly the total increase in a company's stocks presented a very small percentage of sales.

Table 4.11 and Graph 4.11 show the frequency of average productivity on computer simulation. More than 50% of the companies involved with computer simulation had their average productivity on computer simulation not exceeding 27% productivity in general. In another words, the Welsh companies in this sample reflected very low productivity that can only indicate a bad performance in this important field of design and manufacturing.

Average Productivity on CS	Frequency	Cumulative %
0%	58	77%
16%	2	80%
20%	2	83%
27%	4	88%
45%	2	91%
70%	1	92%
80%	3	96%
More	3	100%

Table 4.11 The Frequency of Average Productivity on Computer Simulation as a Percentage of Average Productivity in General.



Graph 4.11

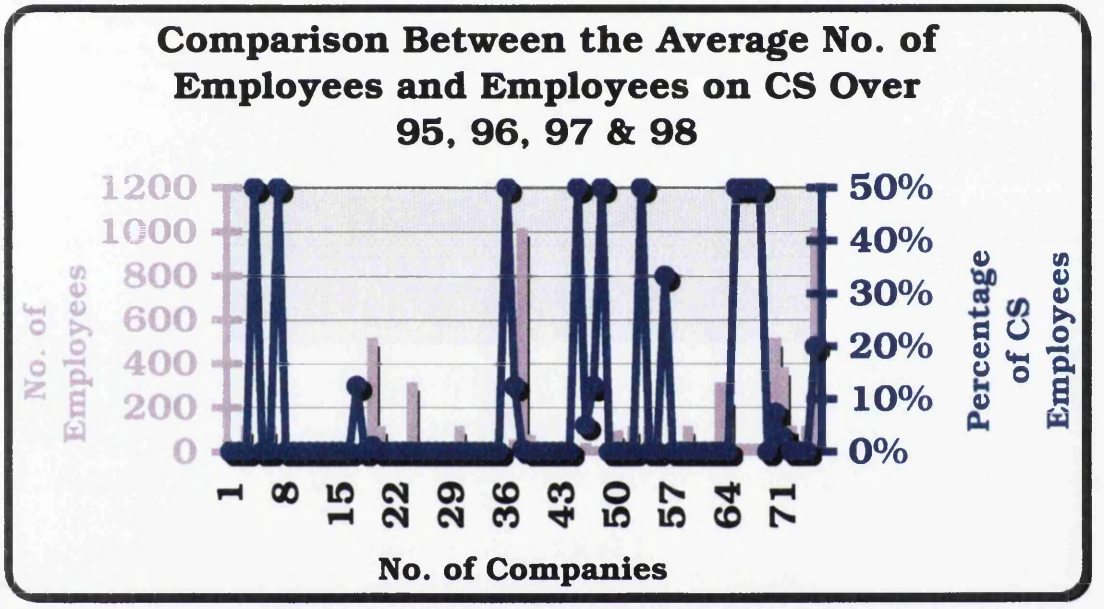
4.6 Companies' Employees on Computer Simulation

Certainly, the percentage of employees on computer simulation reflects the extent of a companies' involvement with computer simulation.

Table 4.12 and Graph 4.12 show that nearly half of the companies involved with computer simulation had allocated an average that is up to 34% of their employees to work on computer simulation.

Average No. of Employees on CS	Frequency	Cumulative %
0%	55	73%
3%	3	77%
7%	1	79%
13%	4	84%
20%	1	85%
34%	1	87%
50%	11	100%

Table 4.12 The Frequency of Average Employees on Computer Simulation as a Percentage of Average Employees in General.



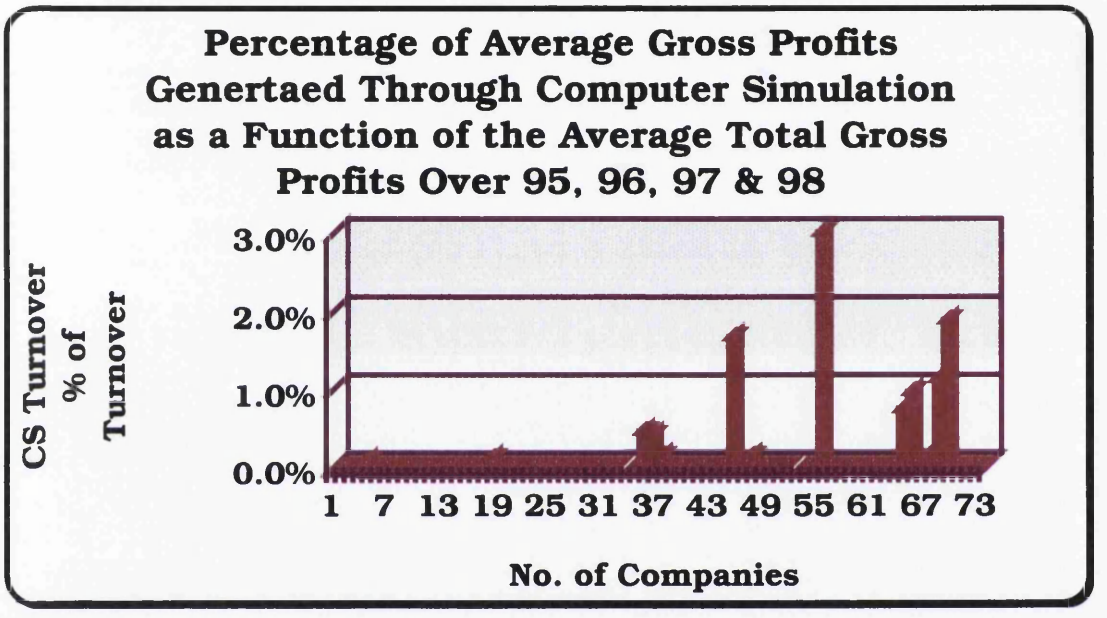
Graph 4.12

4.7 Companies' Profits in Computer Simulation

Analyzing the figures of gross profits of computer simulation as a percentage of total gross profits in this sample of Welsh companies showed, through Table 4.13 and Graph 4.13, that 80% of these companies estimated their gross profits of computer simulation to be around 0.8% of their total gross profits. Even though these estimates might not be very accurate, they agree with other analysis as they show how little Welsh companies are involved with computer simulation.

CS Turnover % of Turnover	Frequency	Cumulative %
0.0%	60	80%
0.1%	2	83%
0.5%	5	89%
1.0%	2	92%
3.0%	3	96%
More	3	100%

Table 4.13 The Frequency of Average Gross Profits on Computer Simulation as a Percentage of Average Gross Profits in General.



Graph 4.13

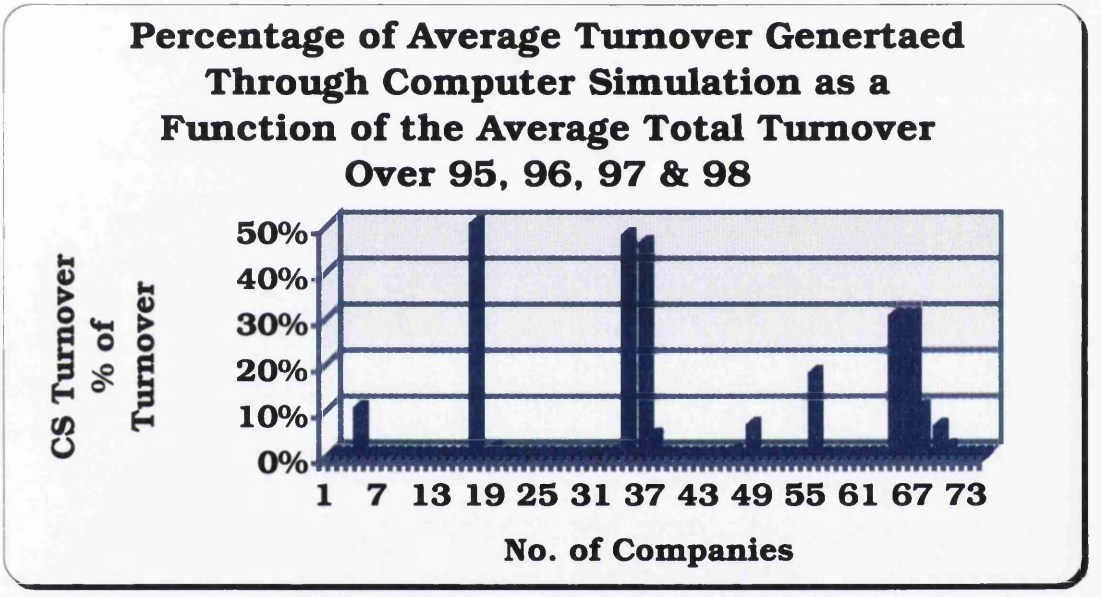
4.8 Companies' Turnover in Computer Simulation

Moving on to the companies' turnover figures expressed in Table 4.14 and Graph 4.14 shows that more than half of the companies that are involved with computer simulation estimated their average computer simulation turnover to be around 4% of their total turnover.

This is another indication to show the low level of involvement and performance of the Welsh companies that work on computer simulation when compared to their general performance.

CS Turnover % of Turnover	Frequency	Cumulative %
0.0%	58	77%
0.5%	2	80%
6.3%	5	87%
10%	2	89%
30%	4	95%
50%	3	99%
More	1	100%

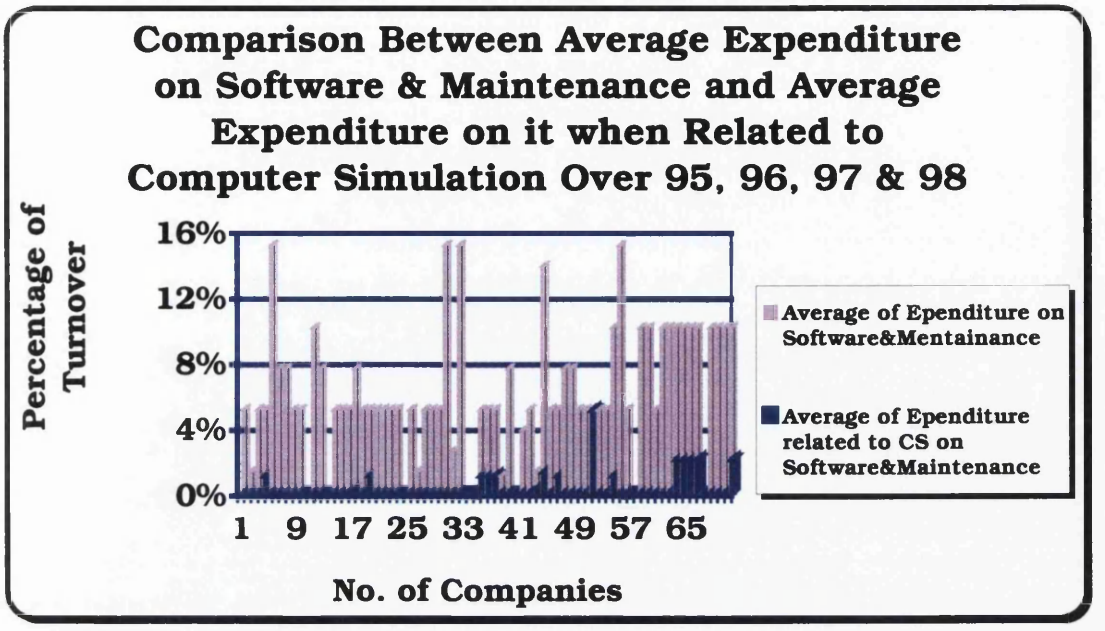
Table 4.14 The Frequency of Average Turnover on Computer Simulation as a Percentage of Average Turnover in General.



Graph 4.14

4.9 Expenditure Related to Computer Simulation on Software & Maintenance and Hardware & Maintenance

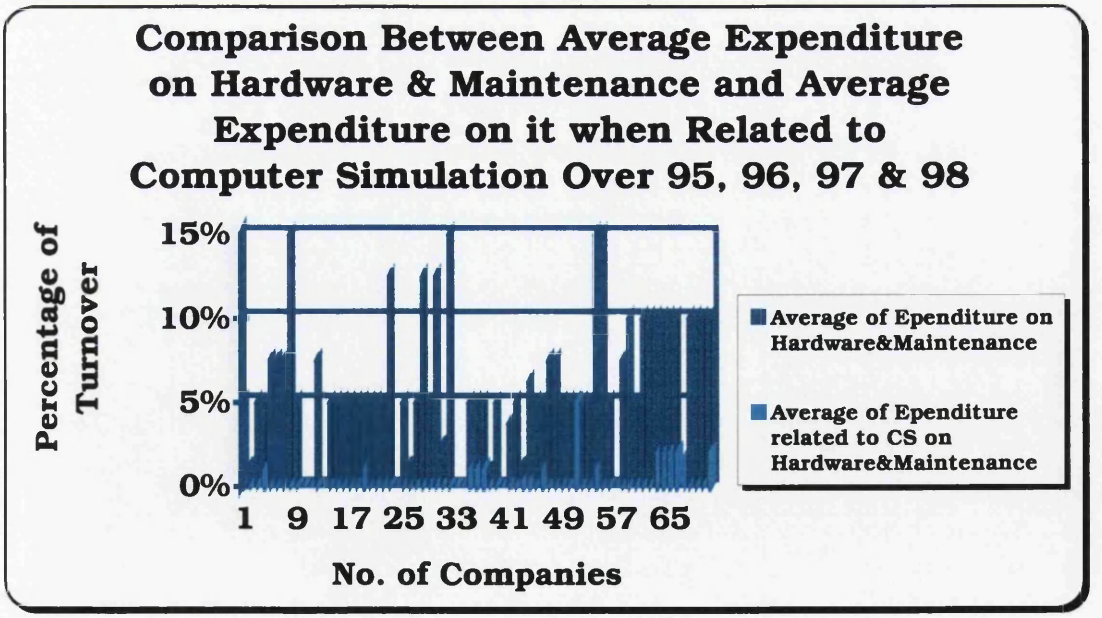
Graph 4.15 shows clearly that the expenditure related to computer simulation on software & maintenance, estimated by the Welsh companies as a percentage of their turnover, is very little compared to expenditure on software & maintenance for the companies in general. Nearly 84% of the companies involved with computer simulation had an estimate for their expenditure on software & maintenance between 1%-2% of their turnover.



Graph 4.15

It is similar case in Graph 4.16 where it is shown that the expenditure related to computer simulation on hardware & maintenance is very little, as 84% of the companies in this sample estimated their expenditure to be between 1%-2% of their turnover.

Hence, the two cases indicate that level of involvement with computer simulation in these companies is very low.



Graph 4.16

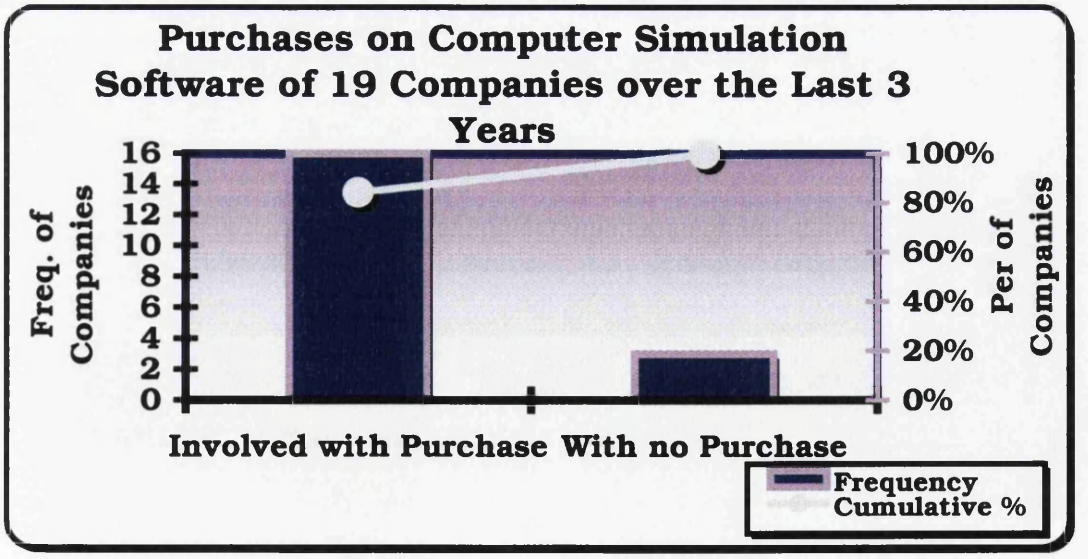
4.10 Computer Simulation View by Welsh Companies

The aim of the last six theoretical questions in the questionnaire was to assess how computer simulation was viewed by Welsh companies in recent years as well as in the near future. As was mentioned before only 24 companies indicated they were involved with computer simulation. However, not all of them answered this set of questions, which brought the sample size down to 19 companies. Every answer will be presented by a table and a graph.

- ✓ When companies were asked about their purchase of computer simulation software, a percentage of 84% of the companies, involved with computer simulation, had purchased computer simulation software in the last three years. This high percentage gives the impression that Welsh companies have somehow a great dependency towards external resources through purchasing. In other words, Welsh companies do not tend to develop their own software.

Purchase on CS Software	Frequency	Cumulative %
Companies Involved with Purchase	16	84%
Companies with no Purchase	3	100%

Table 4.15 Purchases on Computer Simulation Software of 19 Companies over the Last 3 Years

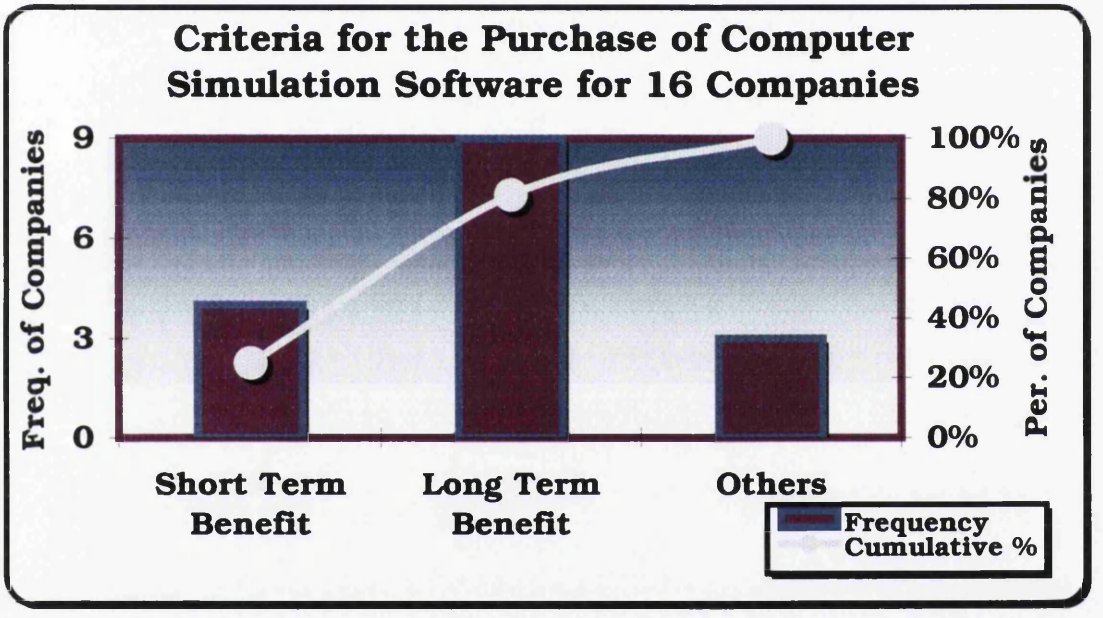


Graph 4.17

- ✓ Now among these companies that purchased computer simulation software in the last three years, 56% considered the long-term benefit, while 44% considered the short-term benefit and other reasons to justify the cost. Because computer simulation is an investment with a long-term benefit, companies with short-term benefit strategy will not normally consider this option.

Criteria for Purchase	Frequency	Cumulative %
Short-Term Benefit	4	25%
Long-Term Benefit	9	81%
Others	3	100%

Table 4.16 Criteria for the Purchase of Computer Simulation Software for 12 Companies

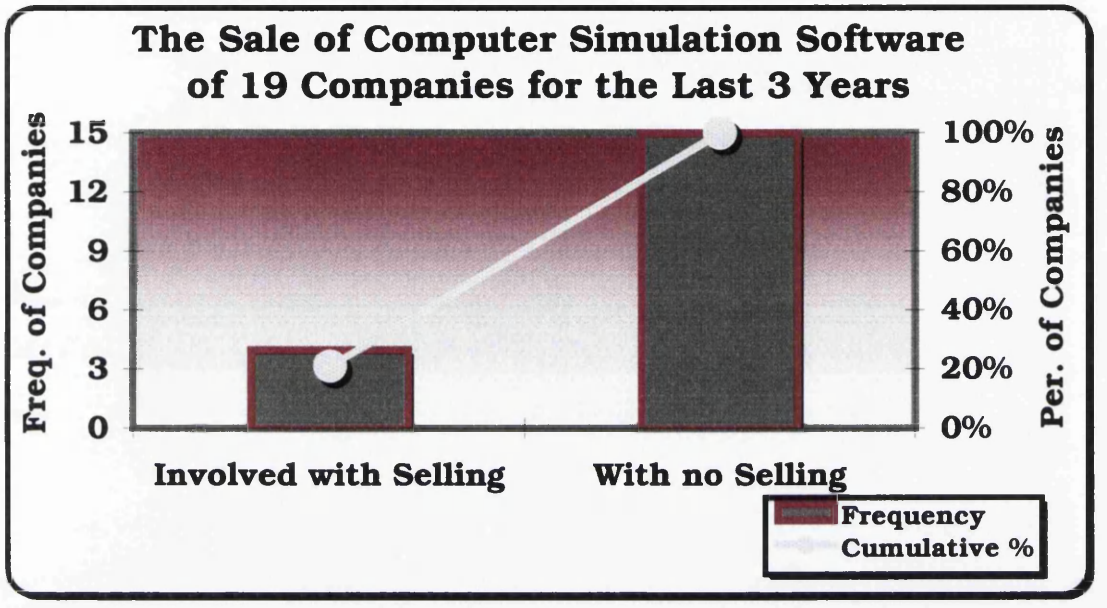


Graph 4.18

- ✓ No more than four companies confirmed they were involved with selling computer simulation software, where 78% of this sample did not sell any computational simulation related product over the last three years. This is another indication from Welsh companies to show their tendency to be dependent on the others.

Sale of CS Software	Frequency	Cumulative %
Companies Involved with Selling	4	21%
Companies with no Selling	15	100%

Table 4.17 The Sale of Computer Simulation Software of 19 Companies for the Last 3 Years

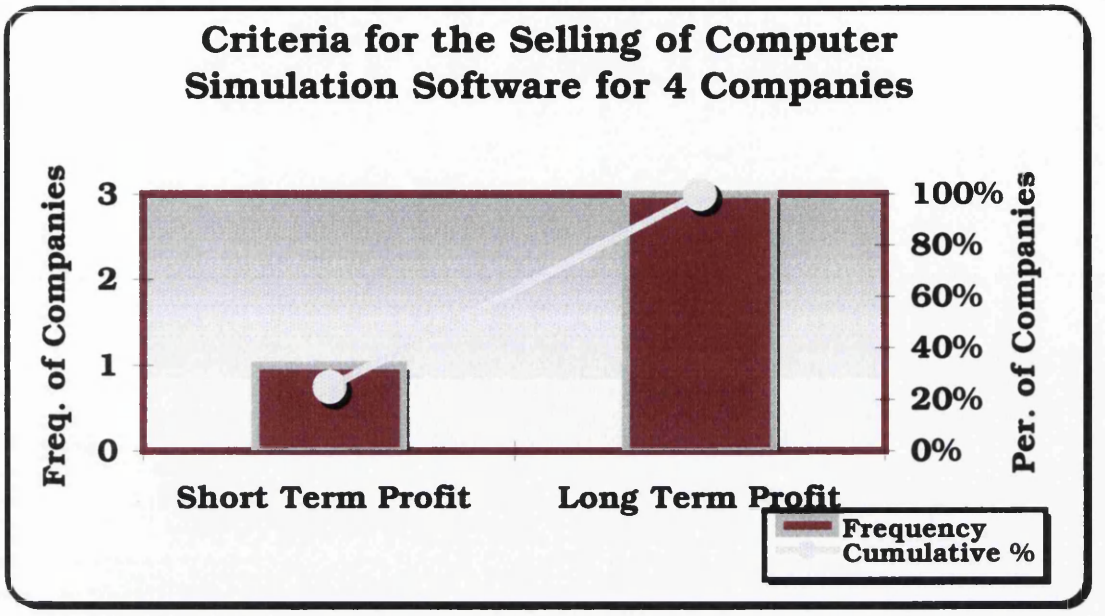


Graph 4.19

- ✓ On the other hand, 75% of the "sellers" considered long-term profits, while 25% of them considered short-term profits. Considering the long-term profit option is one way of marketing computational simulation software, in order to give other companies good and encouraging offers, as the short-term profits option is likely to increase the sale price.

Reasons for Selling	Frequency	Cumulative %
Short -Term Profit	1	25%
Long-Term Profit	3	100%

Table 4.18 Criteria for the Selling of Computer Simulation Software for 4 Companies

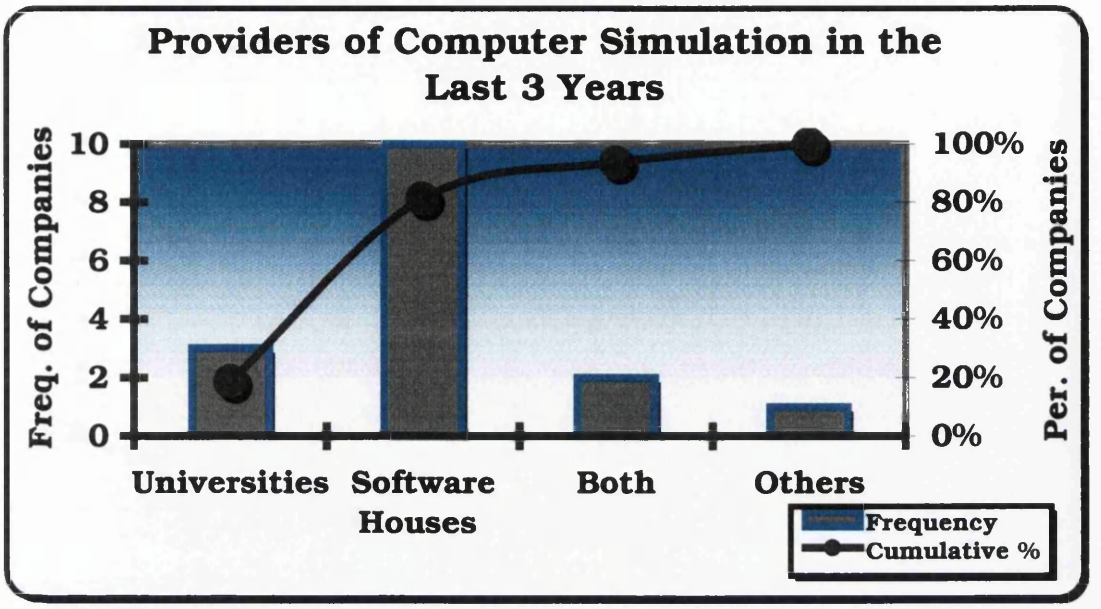


Graph 4.20

- ✓ When asked about their providers of computer simulation, Welsh companies gave away some interesting information. As 18% of them relied on solely universities, 12% relied on universities and software houses together, while 64% got their provision from software houses. This highlights the fact that software houses are the main source of computer simulation provision of companies requirements.

CS Provision	Frequency	Cumulative %
Universities	3	19%
Software Houses	10	81%
Both	2	94%
Others	1	100%

Table 4.19 Providers of Computer Simulation in the Last 3 Years

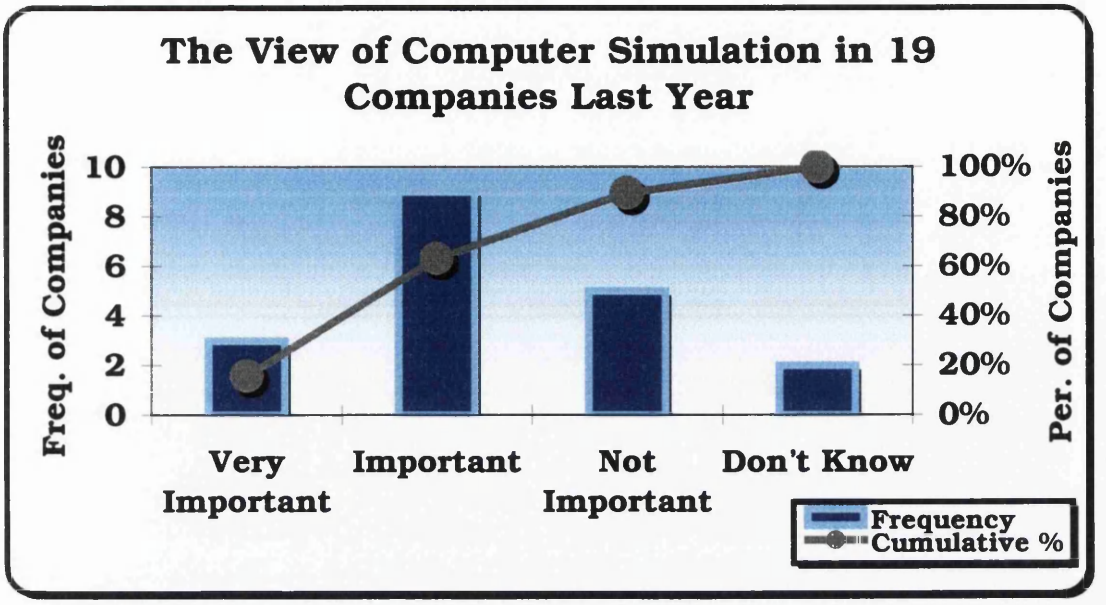


Graph 4.21

- ✓ Finally, the evaluation of computer simulation by this sample of companies. Welsh companies did not sound very aware of the potential of Computational Simulation, not even when they were involved with it. Only, 16% thought computer simulation was very important, while 28% of companies remarked computer simulation as not important.

The View of CS	Frequency	Cumulative %
Very Important	3	16%
Important	9	63%
Not Important	5	89%
Don't Know	2	100%

Table 4.20 The View of Computer Simulation in 19 Companies Last Year


The View of Computer Simulation in 19 Companies Last Year
Freq. of Companies
10
8
6
4
2
0
100%
80%
60%
40%
20%
0%
Per. of Companies
Very Important
Important
Not Important
Don't Know
Frequency
Cumulative %

Graph 4.22

4.11 Conclusions

- The percentage of returned questionnaires was lower than expected. One explanation for this is the companies' directors who received a copy of the questionnaire simply found it irrelevant to their companies, especially that the cover of the questionnaire had this note: This questionnaire is relevant to companies that are involved with computational simulation.
- However, only 16% of the 150 Welsh companies that replied to the questionnaire were involved with computer simulation. This very low percentage reflects serious problems with Welsh industry.
- Interestingly, the prosperous regions in Wales scored very well in terms of involvement with computer simulation, when compared to rural areas. Former Welsh counties; Gwent, West Glamorgan, South Glamorgan and Clwyed have a history of a relative economical revival.
- As an average percentage for this sample of Welsh companies, computer simulation R&D budget appeared to be equal to 1/247 of the total R&D budget. This is a very small percentage, which presents very small figures, in real terms. Welsh companies would not possibly support any computer simulation research or development efficiently with such a small budget. In fact, "one of the difficulties is that R&D is often seen as an area where expenditure can be cut without immediate apparent harm. An emphasis on short-term returns has lowered the perceived value of what is, in effect, wealth development for the long term"[2].
- Neither turnover increases, nor increases in computer simulation turnover, when observed, did lead to any significant changes in a companies' R&D investment. So it is possible that Welsh companies' interests have not extended to computer simulation, and that is why it is not included in their investment plans.
- The indicators for low productivity and low turnover and profits generated through computer simulation, as well as the low percentage of employees employed on computer simulation, and expenditure related to computer simulation on software & maintenance and on hardware & maintenance are factors that indicate the poor performance of Welsh industry in computer simulation.
- Welsh companies tend to purchase computer simulation software rather than sell it. This confirms, in a way, the small figures of R&D budget, as developing Computer modeling software is not taking place in most of these companies.

- There is a great dependency on software houses which highlights that Welsh industrial companies do not consider the welsh university as an alternative for computational simulation provision.
- The way computer simulation is viewed and evaluated by most of the Welsh companies in this sample shows that there is no investment plans, now or in the near future, in computer modeling.

References

[1] C. F. Pratten, A Comparison of the Performance of Swedish and U.K. Companies, Cambridge University Press, 1976.

[2] The importance of UK manufacturing, Manufacturing 2020 Final Report, Foresight, http://www.foresight.gov.uk/default1024ns.htm, 02/2001

Conclusions

- The analysis of the four EPSRC programs showed that with the help of TOP, and naming universities as a target funding for it, EPSRC is spending a considerable budget on computational engineering research, with millions of pounds being spent yearly. Benefits of this research are expected to get back to British industry and have an impact on the economy.
- However, the questionnaire data analysis in Chapter 4 showed how Welsh industrial companies have little interest and little involvement in computer simulation at present and in the near future. In other words, Welsh industry is failing to adapt to the technology of computer simulation or to make proper use of its wide applications and great potential.
- Communication between academia, industry and the different Research Councils, together with initiatives such as Foresight encourage industry to interact more closely with academia.
- In Chapter 4 also, the data analysis showed that the involvement of industrial Welsh companies with computer simulation was much higher in prosperous Welsh counties where access to latest technologies is much easier. Considering the special problematic structure of the Welsh economy, research in Welsh universities should be allowed to play a more essential role in providing industry with a highly qualified workforce and in introducing advanced technology.
- On the other hand, the European Structural Funding that is aiming to promote a sustainable economic growth in Wales can contribute to this by developing and supporting industrial SMEs in Wales to consider more investments in such advanced technology with long-term benefit.

Appendix 1

Mechanical Engineering Programme 1996
Computational Engineering Research Grants

PERIOD OF GRANTS	DURATION (in months)	GRANT REF NO.	GRANT VALUE £ PER YEAR	GRANT VALUE £
18/01/94-17/01/96	24	GR/J 15995	35852	71703
18/01/94-17/01/96	24	GR/J 16558	35852	71703
01/05/93-31/08/96	40	GR/H 80880	33320	111068
01/04/94-31/07/96	40	GR/J 69295	30069	100231
26/09/94-25/09/97	36	GR/J 88012	44406	133218
01/01/93-31/05/96	41	GR/H 75107	46528	158971
01/01/95-31/12/97	24	GR/K 31664	59153	118306
01/10/93-01/10/96	36	GR/J 15100	30667	92000
01/10/94-31/12/96	27	GR/J 49501	48225	108506
01/96 12/98	24	GR/K 55455	55224	110447
01/10/93-30/09/96	36	GR/J 17999	30853	92560
05/93- 04/96	36	GR/H 48156	32974	98923
01/10/95-30/09/98	36	GR/K 54861	31499	94497
01/10/95-30/09/98	36	GR/K 54854	31480	94439
01/06/93-04/07/97	49	GR/J 14011	27314	111534
21/03/94-20/09/97	42	GR/J 52464	59036	206625
29/01/96-28/01/99	36	GR/K 67564	77697	233092
04/94- 03/97	36	GR/J 15490	45333	136000
01/04/93-31/03/96	36	GR/J 13502	0	0
01/12/95-31/11/98	36	GR/K 74211	41381	124142
01/12/93-30/11/96	36	GR/J 06306	31730	95191
01/04/94-31/03/97	36	GR/J 79430	33057	99172
22/06/94-30/04/97	34	GR/J 79423	35668	101059
01/02/94-31/01/97	36	GR/J 74510	0	0
01/10/94-30/09/97	36	GR/J 65631	38212	114637
12/94- 11/97	36	GR/J 88166	66354	199063
01/01/94-31/12/96	24	GR/J 53942	78462	156923
01/10/94-31/10/97	37	GR/J 71601	39892	123000
01/10/93-30/09/96	36	GR/J 07907	39000	117000
01/07/94-30/06/97	36	GR/K 27360	54405	163215
18/04/94-17/04/97	36	GR/J 16565	30597	91792

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01/03/94-28/02/97	36	GR/J 11706	126992	380975
01/10/96-31/12/98	27	GR/K 65164	64381	144857
01/09/94-29/02/96	18	GR/K 04880	0	0
01/11/94-31/10/97	36	GR/K 16791	33820	101459
01/08/93-31/07/96	36	GR/J 54397	53995	161986
01/10/94-30/06/98	45	GR/K 06419	24511	91916
01/03/95-29/02/97	24	GR/K 10690	29429	58858
01/04/94-31/03/96	24	GR/J 67031	43381	86761
01/04/94-31/03/97	36	GR/J 75456	61859	185577
01/10/94-30/09/97	36	GR/K 10478	59485	178454
01/10/95-30/09/98	36	GR/K 56605	69556	208669
01/10/93-30/09/96	36	GR/J 62937	48333	145000
28/03/94-27/03/97	36	GR/J 49525	53212	159636
01/05/94-30/04/97	36	GR/J 73636	41352	124055
01/12/93-31/11/96	36	GR/J 42540	39575	118724
01/11/93-31/10/96	36	GR/J 54260	34443	103328
08/08/94-07/08/97	36	GR/J 78686	45756	137268
01/07/93-30/06/96	36	GR/H 73516	46175	138525
01/94- 03/97	37	GR/J 47002	59862	184573
01/10/95-31/03/97	18	GR/K 64785	115965	173947
01/10/94-30/09/97	36	GR/K 42424	73765	221296
07/04/94-06/04/97	36	GR/J 85813	0	0
01/01/95-31/12/98	36	GR/K 20910	89472	268417
01/10/95-30/09/98	36	GR/K 60985	88202	264605
14/02/94-13/12/97	26	GR/J 65693	0	0
05/93- 06/96	36	GR/H 82136	31686	95058
29/06/94-29/08/97	38	GR/J 82652	38629	122325
01/05/94-31/04/97	36	GR/J 22801	42928	128783
01/10/93-30/09/96	36	GR/J 08355	32926	98778
03/95- 03/97	24	GR/K 13370	48551	97101
19/10/92-18/10/96	48	GR/H 45858	21622	86487
01/10/94-30/09/96	24	GR/K 06556	28143	56285
07/92- 04/96	45	GR/H 41546	17692	66344
01/10/93-30/09/96	36	GR/J 56325	90017	270051
24/02/94-23/02/97	36	GR/J 47347	54453	163359
03/12/93-02/12/96	36	GR/J 47088	39305	117915
10/94- 09/96	24	GR/J 50538	88600	177200
01/05/95-30/09/96	17	GR/J 10297	59314	84028

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01/10/94-30/09/97	36	GR/J 88173	38199	114597
29/04/94-28/09/97	41	GR/J 11652	37582	128405
01/08/94-28/09/97	38	GR/J 11652	40549	128405
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01/09/95-28/02/98	30	GR/K 38649	64054	160135
01/03/93-29/02/96	36	GR/H 78054	38854	116562
11/94- 10/97	36	GR/J 44490	44746	134238
13/11/95-12/11/98	36	GR/K 62484	42009	126027
11/01/93-10/02/96	37	GR/H 77224	36687	113118
01/01/95-30/04/98	40	GR/K 20910	78580	261932
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01/03/95-29/02/98	36	GR/K 04477	32805	98416
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01/04/94-31/03/97	36	GR/J 72721	45359	136078
07/03/94-06/11/96	32	GR/J 46456	42090	112240
01/07/94-30/06/97	36	GR/J 17722	34458	103373
01/02/93-31/01/96	36	GR/H 82679	36735	110206
01/10/93-30/09/96	36	GR/J 58251	76024	228071
01/05/95-30/04/98	36	GR/K 38724	85204	255613
01/01/94-31/12/96	24	GR/J 52242	76749	153498
01/10/94-30/04/98	43	GR/J 90411	65302	234000
04/94- 04/97	36	GR/J 35177	43213	129638
01/09/94-31/08/97	36	GR/J 85578	41213	123639
09/94- 09/97	36	GR/J 81952	33776	101329
01/10/95-30/09/96	12	GR/K 77631	45152	45152
01/04/95-31/03/97	24	GR/K 38700	73790	147579
01/12/95-30/11/96	12	GR/K 55875	226697	226697
01/04/95-31/03/98	36	GR/K 38717	35407	106222
01/04/95-31/03/97	24	GR/K 38694	73000	146000
30/11/93-30/11/96	36	GR/J 62685	48049	144148
01/10/95-30/09/98	36	GR/K 65263	32783	98350
01/10/95-30/09/97	24	GR/K 64013	55967	111934

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01/07/93-30/06/96	36	GR/J 17685	30998	92994
01/10/93-30/09/96	36	GR/J 51658	50451	151352
01/11/93-31/10/96	36	GR/J 48283	57344	172032
04/10/93-04/10/96	36	GR/J 10785	44746	134237
01/03/94-31/10/97	44	GR/J 14622	48784	178874
15/01/95-15/01/98	36	GR/J 75562	51993	155978
01/10/94-30/09/97	36	GR/J 69998	64165	192495
01/02/95-31/08/97	31	GR/K 57466	54423	140593
01/10/93-30/09/96	36	GR/J 48238	40846	122539
01/10/93-30/09/96	36	GR/J 56004	52026	156078
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04/96- 03/98	24	GR/K 63771	35690	71379
12/94- 11/96	24	GR/K 42035	193500	387000
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01/09/93-31/09/96	37	GR/J 42823	0	0
01/08/93-31/07/96	36	GR/J 42861	0	0
01/10/93-30/06-97	45	GR/J 15568	25637	96139
13/05/94-12/12/97	43	GR/J 10143	32160	115240
11/11/92-31/12/96	49	GR/H 77354	30257	123548
01/04/96-31/03/99	36	GR/L 16521	54552	163655
01/10/95-30/09/98	36	GR/K 61388	28337	85010
TOTAL		131	6409411	17463742

Mechanical Engineering Programme 1996
Non-Computational Engineering Research Grants

PERIOD OF GRANTS	DURATION (in months)	GRANT REF NO.	GRANT VALUE £ PER YEAR	GRANT VALUE £
09/94- 08/96	24	GR/J 86902	62466	124931
22/08/94-21/02/96	18	GR/K 29623	42961	64441
01/11/94-31/10/97	36	GR/J 88029	60363	181088
01/05/93-30/04/96	36	GR/J 08393	53416	160248
01/01/96-31/12/98	24	GR/K 62323	63014	126027
30/03/94-30/09/97	42	GR/H 90223	38089	133310
01/01/94-31/12/96	24	GR/J 14356	96978	193956
01/08/93-31/07/96	36	GR/J 14844	42948	128843
10/93- 10/96	36	GR/J 13519	32624	97873
01/10/93-30/09/96	36	GR/J 41901	35493	106479
01/94- 07/96	30	GR/J 94648	1338	3344
01/06/94-31/05/97	36	GR/J 96338	44851	134553
01/10/95-30/09/98	36	GR/K 57664	63338	190013
12/94- 11/97	36	GR/J88166	66354	199063
01/07/95-30/06/97	24	GR/K 64037	31500	63000
01/11/94-31/10/97	36	GR/K 12496	50821	152464
01/10/94-30/09/97	36	GR/K 23263	45102	135306
01/10/95-30/09/97	24	GR/K 63146	74789	149577
10/93- 09/96	36	GR/J 59920	68667	206000
01/06/93-31/08/96	39	GR/J 13991	54572	177360
10/93- 09/96	36	GR/J 46555	61169	183507
01/10/94-01/10/97	36	GR/K 13547	73694	221083
01/01/95-31/12/97	36	GR/K 13622	62808	188424
28/03/94-27/03/97	36	GR/J 08096	45111	135334
01/11/95-31/10/98	36	GR/K 64945	51157	153470
01/11/94-31/08/96	22	GR/K 02626	46083	84485
01/01/95-31/12/97	36	GR/K 03692	22392	67176
01/01/96-31/12/97	12	GR/K 65874	113251	113251
01/09/93-31/08/96	36	GR/J 15322	46906	140719
05/10/92-04/04/96	42	GR/H 46800	27921	97724
01/01/94-31/12/96	36	GR/J 40300	39618	118855

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01/12/93-30/11/96	36	GR/J 10969	60603	181810
17/01/94-16/01/96	24	GR/J 98936	65286	130572
01/09/95-31/08/98	36	GR/K 52928	60903	182708
01/10/95-30/09/96	12	GR/K 70793	52752	52752
01/08/93-31/01/96	30	GR/J 08669	60800	152000
01/10/95-30/09/98	36	GR/K 57527	67319	201958
01/05/93-30/04/96	36	GR/J 09017	73519	220557
01/03/94-28/02/97	36	GR/J 69127	43714	131143
01/10/96-31/12/97	14	GR/K 65201	57271	66816
01/02/96-31/01/98	24	GR/K 65850	32832	65664
01/01/95-31/12/97	36	GR/K 03203	62845	188536
11/07/94-10/07/96	24	GR/J 92477	49681	99362
14/10/94-31/05/97	32	GR/K 25229	35475	94599
01/10/93-01/10/96	36	GR/J 44421	49853	149559
01/10/93-30/09/96	36	GR/J 15575	39835	119506
10/93- 10/96	36	GR/J 14868	46132	138396
07/93- 07/96	36	GR/J 08324	71246	213739
01/03/93-31/08/96	42	GR/H 74810	48783	170740
18/04/94-31/10/97	41	GR/J 46449	31529	107723
01/01/95-31/12/97	36	GR/K 38632	73263	219788
01/05/94-30/04/97	36	GR/J 95072	82129	246387
01/11/93-30/04/97	42	GR/J 62807	95614	334648
12/05/95-11/05/96	12	GR/K 45937	12920	12920
01/04/94-31/03/96	24	GR/H 97376	51670	103339
01/10/93-31/03/96	30	GR/J 10006	42248	105620
01/10/94-31/03/96	18	GR/H 91176	98063	147094
10/95- 09/96	12	GR/J 2620	65071	65071
01/04/94-31/03/97	36	GR/J 93771	97665	292996
01/03/94-28/02/97	36	GR/K 14707	39720	119159
03/95- 08/97	30	GR/K 38663	96611	241528
01/01/93-31/12/96	36	GR/H 26659	68934	206801
01/04/93-31/03/96	36	GR/H 85649	73172	219516
01/10/94-31/09/96	24	GR/K 38731	49859	99717
07/94- 06/96	24	GR/J 88234	30789	61577
01/03/95-28/02/97	24	GR/K 48655	37375	74750
31/12/94-30/12/97	36	GR/J 43356	48905	146716
01/10/93-30/09/96	36	GR/J 15407	66521	199563
01/06/93-31/05/96	36	GR/J 58893	27536	82607

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24/12/94-23/12/97	36	GR/J 06917	30503	91510
06/12/93-05/10/96	34	GR/H 78689	41760	118320
04/94- 04/96	24	GR/H 75206	29500	59000
01/05/94-31/07/97	39	GR/J 12987	48873	158837
10/95- 09/96	12	GR/K 64716	33000	33000
10/93- 09/96	36	GR/H 80606	88647	265942
09/93- 12/96	39	GR/J 61602	47385	154000
01/04/93-30/09/96	41	GR/J 09352	67457	230479
01/10/93-30/09/96	36	GR/J 25550	69296	207887
09/93- 09/96	36	GR/J 40157	33333	100000
01/02/95-01/02/98	36	GR/K 15190	40485	121456
01/09/94-31/08/96	24	GR/K 23812	37183	74365
01/08/93-31/12/96	41	GR/J 15582	27565	94179
10/93- 09/96	36	GR/ 15667	37572	112716
01/04/94-31/03/97	36	GR/K 39509	55955	167866
01/04/94-31/03/97	36	GR/J 15629	45274	135822
10/95- 10/97	24	GR/K 62774	57247	114493
01/09/93-31/08/96	36	GR/J 44711	50968	152905
01/11/95-31/12/97	26	GR/K 80464	5262	11400
01/07/95-30/06/98	36	GR/K 46934	60000	180000
TOTAL		88	4695498	12464018

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Control and Instrumentation Programme 1996
Computational Engineering Research Grants

PERIOD OF GRANTS	DURATION (in months)	GRANT REF NO.	GRANT VALUE £ PER YEAR	GRANT VALUE £
01/03/94-30/06/97	39	GR/J 47736	31590	102668
01/12/95-30/11/97	24	GR/K 70274	40369	131200
01/07/94-30/06/97	36	GR/J 65893	33003	107260
01/01/94-31/12/96	24	GR/J 70956	57230	186000
01/11/94-31/10/97	36	GR/K 07782	41884	136125
07/11/94-06/11/97	36	GR/J 73452	39139	127204
01/10/94-30/09/97	36	GR/K 24987	35101	114081
01/02/95-31/11/98	44	GR/K 34597	28700	93277
27/04/94-26/04/96	24	GR/J 53256	25230	82000
01/09/93-31/08/96	36	GR/J 46432	29832	96955
01/10/95-30/09/98	36	GR/K 82277	63548	206533
22/03/94-21/12/96	21	GR/J 17807	33978	110430
01/10/94-30/09/97	36	GR/J 10136	32253	104823
01/12/93-30/11/96	36	GR/J 4235	31216	101453
23/08/93-22/05/96	33	GR/H 55741	58153	189000
01/11/93-30/10/96	36	GR/J 21729	43082	140018
01/10/95-30/09/98	36	GR/K 76573	71961	233875
01/10/95-30/09/96	12	GR/K 62996	8571	27857
01/01/94-03/05/97	40	GR/J 53706	38415	124849
24/04/95-23/04/98	36	GR/K 79499	29606	96220
01/03/94-28/02/97	36	GR/J 67208	25076	81500
01/09/94-31/08/97	36	GR/J 66799	45176	146825
18/10/93-17/10/96	36	GR/J 43820	31184	101348
01/11/94-31/10/97	36	GR/K 36300	27618	89759
15/01/95-14/01/97	24	GR/K 31510	61811	200887
01/01/94-31/12/96	24	GR/J 32213	33846	110000
01/03/95-28/02/98	36	GR/K 07959	37423	121625
01/02/95-31/01/97	24	GR/K 37239	24821	80671
01/07/95-30/06/97	24	GR/K 31343	24695	80259
01/08/95-31/07/98	36	GR/K 64310	41396	134540
02/93- 07/96	42	GR/H 73585	77478	251806

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01/11/93-31/10/96	36	GR/J 15797	30159	98017
12/04/93-11/04/96	36	GR/H 39451	20796	67588
25/10/93-24/10/96	36	GR/J 48344	30783	100046
03/04/95-02/04/99	48	GR/K 07317	41270	134128
01/04/95-31/03/97	24	GR/K 36775	17216	55954
01/09/95-31/08/98	36	GR/K 18504	24620	80017
01/10/95-30/09/98	36	GR/K 54465	40828	132691
01/08/95-31/07/98	36	GR/K 56216	40808	132627
01/12/94-30/11/96	24	GR/J 79348	42823	139175
01/03/95-28/02/98	36	GR/K 00738	33538	109000
01/12/94-30/11/96	24	GR/K 34665	32923	107000
01/09/94-31/08/97	36	GR/J 67130	31530	102474
01/04/95-31/03/98	36	GR/J 77658	39624	128780
01/09/94-31/08/96	24	GR/J 71687	16315	53024
11/10/93-11/10/96	36	GR/J 48160	31384	102000
01/07/95-30/06/97	24	GR/K 26936	15008	48779
15/03/94-14/03/97	36	GR/J 42311	41852	136020
TOTAL		48	1734882	5638368

Control and Instrumentation Programme 1996
Non-Computational Engineering Research Grants

PERIOD OF GRANTS	DURATION (in months)	GRANT REF NO.	GRANT VALUE £ PER YEAR	GRANT VALUE £
01/01/94-30/06/96	30	GR/J 45947	47748	119369
06/11/95-05/11/97	24	GR/K 63498	36900	73800
01/04/95-31/03/98	36	GR/K 37116	41526	124579
01/07/95-30/06/97	24	GR/K 23584	48822	97643
01/12/94-30/11/97	36	GR/J 78075	39562	118685
01/10/94-30/09/97	36	GR/J 92989	39125	117376
11/93- 10/96	36	GR/J 49679	44333	133000
01/04/95-30/04/97	24	GR/K 67762	31254	62508
01/03/94-28/02/97	36	GR/J 06955	57242	171727
15/05/94-14/05/96	24	GR/J 43554	58122	116243
05/06/95-04/06/97	24	GR/K 26943	33885	67770
01/07/95-30/06/96	12	GR/K 64372	44528	44528
13/05/94-12/02/97	33	GR/J 87817	53800	147950
09/01/95-08/01/97	24		33698	67395
01/01/95-31/12/97	24	GR/K 34566	72040	144080
01/03/94-28/02/97	36	GR/J 08362	33551	100653
21/05/95-20/05/98	36	GR/K 35815	38062	114186
01/11/94-30/04/98	42	GR/K 35471	40898	143142
01/10/95-30/09/98	36	GR/K 52270	42467	127400
01/01/94-30/06/97	42	GR/J 46531	53590	187564
01/09/94-31/10/96	24	GR/J 13892	57649	115298
01/04/95-31/03/98	36	GR/K 11147	57293	171878
06/02/95-05/08/97	30	GR/K 35761	33108	82771
01/11/95-01/11/97	24	GR/J 87329	47220	94439
01/10/95-30/09/96	12	GR/K 64938	37120	37120
01/01/94-31/12/96	24	GR/J 16985	60523	121046
01/04/93-30/06/96	38	GR/H 85076	59053	187000
01/04/94-31/03/97	36	GR/J 65334	8951	26853
01/10/94-30/09/97	36	GR/K 09410	34667	104000
01/09/93-31/08/96	36	GR/J 13229	50909	152727
01/08/94-01/08/96	24	GR/K 34658	54409	108817

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01/11/95-30/10/96	12	GR/K 62361	35802	35802
01/10/95-31/07/97	22	GR/K 34696	51887	95127
01/10/93-30/09/96	36	GR/J 60728	37292	111877
01/11/94-31/10/97	36	GR/K 04378	54216	162649
01/07/95-30/06/98	36	GR/K 17224	43316	129947
01/12/95-30/11/97	24	GR/K 65867	43500	87000
01/03/95-28/02/98	36	GR/K 37161	34282	102845
01/11/93-31/10/96	36	GR/J 51498	39961	119882
01/08/94-31/07/97	36	GR/K 36553	40609	121827
01/10/94-30/09/96	24	GR/J 92637	34719	69437
01/11/93-30/06/96	32	GR/J 123990	30273	80729
01/07/94-30/06/97	36	GR/J 75241	43492	130477
01/10/93-30/09/96	36	GR/J 05149	37312	111936
01/10/94-30/09/97	36	GR/K 36171	51705	155114
01/03/96-28/02/98	24	GR/K 62392	46500	93000
01/02/94-31/01/97	36	GR/J 42618	31667	95000
01/10/95-30/09/97	24	GR/K 65027	58616	117231
01/10/94-30/09/97	36	GR/K 24895	81542	244627
01/06/95-31/05/98	36	GR/K 36478	56667	170000
04/10/93-03/04/96	30	GR/J 12260	48120	120300
24/08/94-23/11/97	39	GR/J 16299	29585	96152
01/09/94-31/08/97	36	GR/K 38021	26152	78455
21/05/95-20/01/97	28	GR/K 22747	25286	59000
01/10/94-30/09/97	36	GR/K 35976	36778	110333
06/11/94-05/11/97	36	GR/K 09373	33234	99703
TOTAL		56	2444563	6279997

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Design and Integrated Programme 1996
Computational Engineering Research Grants

PERIOD OF GRANTS	DURATION (in months)	GRANT REF NO.	GRANT VALUE £ PER YEAR	GRANT VALUE £
01/02/94 - 31/01/97	36	GR/J61473	58333	175000
01/08/94 - 31/07/98	48	GR/K22273	92389	369555
01/11/93 - 31/10/96	36	GR/K30513	44740	134221
01/09/95 - 31/08/98	36	GR/K68004	23477	70430
01/05/94 - 31/10/97	42	GR/K31268	68000	238000
01/01/95 - 30/06/97	30	GR/K31855	54237	135592
	12	GR/K31916	24173	24173
01/01/93 - 30/06/96	42	GR/H85434	53598	187592
01/01/93 - 31/07/96	43	GR/J18712	68156	244227
01/05/93 - 31/10/96	42	GR/J40812	41127	143945
	24	GR/J40713	54936	109871
01/10/94 - 30/09/97	36	GR/K42370	8308	24925
22/03/93 - 21/06/96	39	GR/H90346	66769	217000
01/10/95 - 30/09/97	38	GR/J41765	41885	132635
01/07/93 - 30/06/96	36	GR/J11409	93172	279517
01/06/93 - 30/11/96	42	GR/528550	77143	270000
TOTAL	16		870443	2756683

Design and Integrated Programme 1996
Non-Computational Engineering Research Grants

PERIOD OF GRANTS	DURATION (in months)	GRANT REF NO.	GRANT VALUE £ PER YEAR	GRANT VALUE £
01/10/95 - 30/09/96	12	GR/K72230	30078	30078
18/03/96 - 17/03/99	36	GR/K82666	35814	107441
13/11/95 - 12/11/98	36	GR/K95376	70667	212000
01/08/94 - 31/07/98	48	GR/K22273	138583	554333
17/07/95 - 16/07/98	36	GR/K95613	32091	96273
01/09/95 - 31/08/98	36	GR/K79383	57703	173110
01/10/93 - 30/09/96	36	GR/J23679	49030	147090
01/05/94 - 30/04/97	36	GR/J90466	43960	131879
26/10/94 - 25/10/97	36	GR/K41298	87333	262000
11/01/93 - 10/07/96	42	GR/J19009	90077	315268
01/05/95 - 31/04/98	36	GR/K42561	82967	248902
24/01/94 - 31/03/96	26	GR/J93597	69201	149935
01/10/95 - 31/12/97	36	GR/K26226	60000	180000
01/02/94 - 31/01/97	36	GR/K65303	105667	317000
01/07/94 - 30/06/97	36	GR/K21762	58300	174901
01/10/94 - 30/09/97	36	GR/K31756	61857	185571
01/03/94 - 01/02/97	35	GR/J45589	71657	209000
01/11/92 - 01/03/96	46	GR/J19023	68870	264000
11/12/95 - 10/06/97	18	GR/K70731	41008	61512
01/06/93 - 30/06/96	37	GR/J47774	33701	103911
01/10/94 - 31/03/97	30	GR/K32548	85768	214421
27/03/95 - 26/03/98	36	GR/K48006	50439	151316
01/01/95 - 31/12/97	24	GR/K48228	79822	159643
07/11/94 - 06/11/97	36	GR/K32456	29736	89207
31/10/94 - 30/10/97	36	GR/K31398	135333	406000
28/11/94 - 27/11/97	36	GR/K41472	51045	153134
01/06/95 - 31/05/98	36	GR/K56995	53000	159000
01/09/94 - 30/11/97	37	GR/J7878	50270	155000
01/10/94 - 30/06/98	39	GR/K35086	204750	665436
07/01/93	48	GR/J08515	375017	1500068
01/10/95 - 31/12/98	39	GR/K47368	617603	2007211

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01/01/95 - 31/12/97	24	GR/K48228	79822	159643
07/11/94 - 06/11/97	36	GR/K32456	29736	89207
01/05/94 - 30/05/96	25	GR/J50217	39195	81656
10/05/93 - 09/05/96	36	GR/J18958	71667	215000
02/06/94 - 19/06/96	24	GR/J95300	30800	61600
10/11/95 - 09/11/96	12	GR/K95246	6943	6943
01/04/95 - 31/03/97	24	GR/K42844	47797	95593
01/02/95 - 31/01/98	36	GR/K39417	33667	101000
01/08/93 - 01/01/97	41	GR/J57735	45333	154888
01/05/95 - 30/04/98	36	GR/K69728	46918	140754
01/10/95 - 30/09/98	36	GR/K95758	101063	303190
01/05/95 - 30/04/97	24	GR/K42851	48513	97025
01/01/94 - 31/12/96	24	GR/J84656	125081	250162
01/06/94 - 31/05/97	36	GR/K24567	97723	293168
09/08/95 - 08/11/96	15	GR/K74340	2640	3300
10/04/95 - 09/04/98	36	GR/K39400	41465	124394
17/10/94 - 16/10/96	24	GR/K47009	79922	159844
01/10/94 - 31/03/96	30	GR/K46477	30521	76303
01/09/93 - 31/12/96	40	GR/J59173	60296	200986
01/08/94 - 31/10/97	39	GR/K21252	77406	251569
01/03/95 - 31/03/98	37	GR/K48020	84000	259000
10/07/95 - 09/07/98	36	GR/J67175	36588	109763
01/05/94 - 30/04/98	48	GR/K31374	123571	494285
31/12/95 - 30/12/99	48	GR/K78096	78086	312342
01/08/94 - 31/07/98	48	GR/K31381	126579	506317
13/09/93 - 12/09/96	36	GR/J57568	34094	102281
06/02/95 - 05/04/98	38	GR/K41823	86350	273442
15/09/94 - 14/09/97	36	GR/K40901	41905	125714
01/03/93 - 29/02/96	36	GR/H49603	51178	153533
01/07/94 - 30/06/97	36	GR/J97922	38770	116311
01/05/95 - 31/01/98	33	GR/K36348	37782	103900
06/06/94 - 05/09/96	24	GR/K23591	43399	86797
	12	GR/K24284	30583	30583
01/07/93 - 31/12/96	42	GR/J14165	49794	174278
25/01/93 - 24/01/96	36	GR/J19887	42333	127000
26/11/92 - 20/05/96	42	GR/H25016	27881	97582
01/01/95 - 31/12/97	36	GR/K26226	47667	143000
01/10/94 - 31/09/98	48	GR/K19525	275000	1100000

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10/04/95 - 09/04/98	36	GR/K47931	40120	120360
01/10/95 - 30/09/96	12	GR/K56001	14000	14000
01/12/92 - 31/05/96	42	GR/H79402	42623	149179
01/06/94 - 31/06/97	36	GR/95294	97518	292553
01/07/95 - 30/06/98	36	GR/K47818	32605	97815
18/04/94 - 17/07/96	27	GR/J97458	42970	96683
13/05/94 - 12/05/98	48	GR/K29142	130096	520383
05/08/93 - 04/02/96	30	GR/J59906	39070	97674
01/07/95 - 30/06/98	36	GR/K48198	32605	97815
29/11/93 - 28/11/96	36	GR/J40348	111632	334895
01/10/95 - 30/05/97	20	GR/K61845	51063	85105
04/04/93 - 04/05/96	36	GR/J07167	98222	294665
01/12/95 - 30/11/98	36	GR/K82116	30497	91492
01/05/95 - 30/04/98	36	GR/K50504	73878	221635
01/08/93 - 31/01/96	30	GR/J57827	240571	601428
01/05/95 - 30/05/98	37	GR/K50511	42003	129508
01/09/95 - 30/11/97	27	GR/K64921	39140	88064
29/04/94 - 28/08/97	40	GR/J60315	77200	257334
01/05/95 - 30/04/98	36	GR/K50528	45405	136216
01/05/95 - 30/04/98	36	GR/K50535	78241	234723
15/11/93 - 14/11/96	36	GR/J68410	49000	147000
01/11/95 - 31/10/98	36	GR/K70168	80699	242098
01/10/95 - 31/03/98	30	GR/K48365	61252	153129
01/09/95 - 30/08/98	36	GR/K69346	44921	134764
15/11/95 - 14/11/98	36	GR/K79765	85026	255077
01/09/94 - 31/08/97	36	GR/K32227	42969	128906
01/10/94 - 20/09/96	24	GR/K32746	34819	69637
01/04/95 - 31/03/97	24	GR/K42844	47797	95593
01/07/94 - 30/09/97	39	GR/J6385	82663	268656
01/10/93 - 30/09/96	36	GR/J20111	54504	163512
19/06/95 - 18/06/98	36	GR/K01421	33063	99190
19/04/94 - 18/10/97	42	GR/J57353	53425	186989
01/01/94 - 31/12/96	24	GR/J91852	150365	300729
01/10/94 - 30/09/96	24	GR/J65426	26845	53689
01/10/94 - 30/09/97	36	GR/K32869	50498	151495
01/08/94 - 31/07/97	36	GR/K07041	670000	2010000
25/11/91 - 24/11/94	36		55360	166080
01/08/94 - 01/02/97	30		73130	182825

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01/12/94 - 30/11/96	24	QREP/MAY95	49282	98563
01/05/93 - 01/07/96	38	GR/K07041	211579	670000
01/08/94 - 01/07/98	47	QREP/JAN96	32382	126828
01/10/95 - 30/09/98	36	GR/K97233	51410	154229
01/10/94- 31/03/97	30	GR/J10396	49438	123596
01/06/94 - 31/05/97	36	GR/J97748	67062	201185
01/11/94 - 31/10/97	36	GR/J95607	70000	210000
01/03/94 - 31/03/97	37	GR/J90022	82934	255712
09/05/95 - 08/05/98	36	GR/K38472	85491	256472
10/07/95 - 30/12/97	30	GR/K76535	65996	164990
01/01/96 - 30/12/97	12	GR/K76542	78806	78806
01/01/96 - 30/12/97	12	GR/K76559	79524	79524
01/02/94 - 31/01/97	36	GR/J48869	76000	228000
09/11/93 - 08/11/96	36	GR/J57773	107640	322920
18/07/94 - 17/07/97	36	GR/K39844	116824	350472
01/01/95 - 31/12/97	36	GR/K47290	78490	235470
01/10/93 - 30/09/97	48	GR/J41765	132636	530542
30/01/93 - 29/10/96	33	GR/H43526	34545	95000
16/02/94 - 15/07/96	29	GR/J95010	51310	124000
01/10/94 - 30/06/97	33	GR/J59241	103955	285875
01/01/94 - 31/12/97	36	GR/J72066	208833	626500
24/10/93 - 23/10/96	36	GR/J59180	9421	28262
18/10/93 - 17/10/96	36	GR/J64047	51667	155000
01/01/94 - 31/12/96	24	GR/J49785	109726	219452
01/07/94 - 31/10/96	28	GR/K32555	29838	69621
10/07/95 - 30/12/97	18	GR/K76535	109993	164990
01/01/96 - 30/12/97	12	GR/K76542	78806	78806
01/01/96 - 30/12/97	12	GR/K76559	79524	79524
09/08/93 - 08/08/96	36	GR/J40119	47667	143000
29/04/94 - 28/04/97	36	GR/K00233	28690	86070
01/06/95 - 31/05/98	36	GR/K51105	85333	256000
01/10/94 - 31/09/97	36	GR/J39960	92614	277841
01/10/95 - 30/09/98	36	GR/K70137	91168	273504
01/04/93 - 31/12/96	33	GR/J06856	42545	117000
01/01/95 - 31/12/97	24	GR/K41588	116510	233019
01/11/95 - 31/10/98	36	GR/K81959	125907	377720
01/07/95 - 30/06/98	36	GR/K48174	32605	97815
01/11/94 - 30/10/96	24	GR/K11468	84997	169994

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01/11/93 - 30/04/97	42	GR/J54864	122531	428857
01/10/95 - 30/09/98	36	GR/K96304	53312	159935
10/07/95 - 30/12/97	29	GR/K76535	68272	164990
01/01/96 - 30/07/97	19	GR/K76542	49772	78806
01/10/96 - 30/12/97	15	GR/K76559	63619	79524
01/07/94 - 30/06/97	36	GR/K21762	58300	174901
01/10/94 - 30/09/97	36	GR/K31756	61857	185571
08/06/93 - 07/03/97	45	GR/J56851	40972	153644
01/09/95 - 31/08/98	36	GR/K81829	53667	161000
01/08/93 - 31/07/96	36	GR/J57544	70829	212487
19/06/95 - 18/06/96	12	GR/K61517	11317	11317
01/10/95 - 30/09/97	24	GR/K69827	53684	107368
03/07/93 - 02/07/96	36	GR/J13458	29718	89153
29/10/93 - 28/10/96	36	GR/J21323	84333	252999
01/10/93 - 30/09/96	36	GR/J09086	39589	118768
TOTAL	160		12342117	35963511

General Engineering Programme 1997
Computational Engineering Research Grants

ORGANISATION	GRANT VALUE £
BATH UNIVERSITY	180063
BATH UNIVERSITY	86655
BIRMINGHAM UNIVERSITY	205262
BRADFORD UNIVERSITY	47690
BRISTOL UNIVERSITY	87820
BRISTOL UNIVERSITY	93565
CAMBRIDGE UNIVERSITY	161702
CITY UNIVERSITY	89235
CITY UNIVERSITY	202943
CRANFIELD UNIVERSITY	53279
DUNDEE UNIVERSITY	140638
EXETER UNIVERSITY	125772
EXETER UNIVERSITY	138616
HERIOT-WATT UNIVERSITY	52413
HERIOT-WATT UNIVERSITY	12435
HERIOT-WATT UNIVERSITY	52853
HULL UNIVERSITY	256298
HULL UNIVERSITY	129966
IMPERIAL COLLEGE OF SCIENCE	50349
IMPERIAL COLLEGE OF SCIENCE	205497

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LIVERPOOL UNIVERSITY	162256
LOUGHBOROUGH UNIVERSITY	163006
NOTTINGHAM UNIVERSITY	90623
NOTTINGHAM UNIVERSITY	49274
NOTTINGHAM UNIVERSITY	111793
OPEN UNIVERSITY	49601
OXFORD UNIVERSITY	36084
SALFORD UNIVERSITY	177931
SALFORD UNIVERSITY	201990
SHEFFIELD UNIVERSITY	50145
SHEFFIELD UNIVERSITY	51280
SHEFFIELD UNIVERSITY	79056
SHEFFIELD UNIVERSITY	170842
SOUTH BANK UNIVERSITY	114893
SOUTHAMPTON UNIVERSITY	51878
ST MARYS HOSPITAL MEDICAL SCH	14689
STARTHCLYDE UNIVERSITY	72394
STARTHCLYDE UNIVERSITY	51164
THE UNIVERSITY OF SURRY	39377
UMITS	61331
UMITS	121062
UMITS	171713
UNIV OF ULSTER AT COLERAINE	131458
UNIV OF ULSTER AT COLERAINE	1992
UNIV WALES, ABERYSTWYTH	93553

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UNIV WALES, SWANSEA	126186
UNIV WALES, SWANSEA	197449
UNIV WALES, SWANSEA	207207
UNIV WALES, SWANSEA	44618
UNIVERSITY COLLEGE LONDON	89819
UNIVERSITY COLLEGE LONDON	99163
UNIVERSITY OF MANCHESTER	50010
UNIVERSITY OF MANCHESTER	109053
UNIVERSITY OF WALES, CARDIFF	343143
TOTAL	5959084

General Engineering Programme 1997
Non-Computational Engineering Research Grants

ORGANISATION	GRANT VALUE £
ABERDEEN UNIVERSITY	111894
ABERDEEN UNIVERSITY	41130
ABERDEEN UNIVERSITY	86471
ASTON UNIVERSITY	5500
ASTON UNIVERSITY	126463
BATH UNIVERSITY	119861
BATH UNIVERSITY	195513
BATH UNIVERSITY	122595
BRADFORD UNIVERSITY	175999
BRIGHTON UNIVERSITY	55674
BRISTOL UNIVERSITY	16887
BRISTOL UNIVERSITY	52977
BRITISH GEOLOGICAL SURVAY	85284
BRUNEL UNIVERSITY	142645
BUILDING RESEARCH ESTAB	70924
CAMBRIDGE UNIVERSITY	117413
CAMBRIDGE UNIVERSITY	124333
CAMBRIDGE UNIVERSITY	47030
CAMBRIDGE UNIVERSITY	164716
CAMBRIDGE UNIVERSITY	209920
CAMBRIDGE UNIVERSITY	106502
CAMBRIDGE UNIVERSITY	8120

Appendix 4

CAMBRIDGE UNIVERSITY	140019
CAMBRIDGE UNIVERSITY	53593
CAMRIDGE UNIVERSITY	253613
CAMBRIDGE UNIVERSITY	50042
CAMBRIDGE UNIVERSITY	49518
CAMBRIDGE UNIVERSITY	47244
CAMBRIDGE UNIVERSITY	50223
CAMBRIDGE UNIVERSITY	109299
CAMBRIDGE UNIVERSITY	1530
CAMBRIDGE UNIVERSITY	118823
CITY UNIVERSITY	78065
CRANFIELD UNIVERSITY	184914
CRANFIELD UNIVERSITY	19426
CRANFIELD UNIVERSITY	51921
CRANFIELD UNIVERSITY	113658
CRANFIELD UNIVERSITY	209638
DUNDEE UNIVERSITY	208377
ESTAMAN DENTAL INSTITUTE	58548
ESTAMAN DENTAL INSTITUTE	56777
ESTAMAN DENTAL INSTITUTE	173426
ESTAMAN DENTAL INSTITUTE	
ESTAMAN DENTAL INSTITUTE	48630
EXETER UNIVERSITY	16612
GLAMORGAN UNIVERSITY	101769
GLASGOW UNIVERSITY	275533
GLASGOW UNIVERSITY	49693
GLASGOW UNIVERSITY	48781
GREENWICH UNIVERSITY	66363
GREENWICH UNIVERSITY	39786
HERIOT-WATT UNIVERSITY	152356

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HERIOT-WATT UNIVERSITY	74382
HERIOT-WATT UNIVERSITY	51529
HERIOT-WATT UNIVERSITY	51569
IMPERIAL COLLEGE OF SCIENCE	39161
IMPERIAL COLLEGE OF SCIENCE	3370
IMPERIAL COLLEGE OF SCIENCE	214091
IMPERIAL COLLEGE OF SCIENCE	140586
IMPERIAL COLLEGE OF SCIENCE	86809
IMPERIAL COLLEGE OF SCIENCE	154397
IMPERIAL COLLEGE OF SCIENCE	124121
IMPERIAL COLLEGE OF SCIENCE	226207
IMPERIAL COLLEGE OF SCIENCE	12580
IMPERIAL COLLEGE OF SCIENCE	120951
KENT UNIVERSITY	194304
KINGS COLLEGE LONDON	43024
KINGS COLLEGE LONDON	42349
KINGS COLLEGE LONDON	154207
KINGS COLLEGE LONDON	146123
KINGS COLLEGE LONDON	129323
KINGSTON UNIVERSITY	110978
KINGSTON UNIVERSITY	66410
LEEDS UNIVERSITY	53730
LEEDS UNIVERSITY	50000
LEEDS UNIVERSITY	172364
LEEDS UNIVERSITY	37454
LEEDS UNIVERSITY	130418
LEEDS UNIVERSITY	101262
LEEDS UNIVERSITY	151347
LEEDS UNIVERSITY	24027
LEEDS UNIVERSITY	148561
LEEDS UNIVERSITY	48417
LEEDS UNIVERSITY	53027
LEEDS UNIVERSITY	115041

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LEEDS UNIVERSITY	2950
LIVERPOOL UNIVERSITY	153537
LIVERPOOL UNIVERSITY	109101
LIVERPOOL UNIVERSITY	154100
LIVERPOOL UNIVERSITY	147762
LOUGHBOROUGH UNIVERSITY	161793
LOUGHBOROUGH UNIVERSITY	152338
LOUGHBOROUGH UNIVERSITY	161719
LOUGHBOROUGH UNIVERSITY	46477
LOUGHBOROUGH UNIVERSITY	117904
NAPIER UNIVERSITY	80219
NEWCASTLE UNIVERSITY	165669
NEWCASTLE UNIVERSITY	103924
NEWCASTLE UNIVERSITY	195301
NEWCASTLE UNIVERSITY	211291
NORTH EAST WALES INST OF HE	121451
NOTTINGHAM UNIVERSITY	199649
NOTTINGHAM UNIVERSITY	1500
NOTTINGHAM UNIVERSITY	178662
NOTTINGHAM UNIVERSITY	163859
NOTTINGHAM UNIVERSITY	236187
NOTTINGHAM UNIVERSITY	37071
NOTTINGHAM UNIVERSITY	80590
NOTTINGHAM UNIVERSITY	140580
NOTTINGHAM UNIVERSITY	168667
NOTTINGHAM UNIVERSITY	22341
OPEN UNIVERSITY	80252
OPEN UNIVERSITY	65210
OPEN UNIVERSITY	2032
OXFORD UNIVERSITY	181357

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OXFORD UNIVERSITY	87150
QUEEN MARY & WESTFIELD COLLEGE	112961
QUEEN'S UNIVERSITY OF BELFAST	132222
QUEEN'S UNIVERSITY OF BELFAST	170808
READING UNIVERSITY	142271
READING UNIVERSITY	32118
READING UNIVERSITY	189727
SALFORD UNIVERSITY	77727
SALFORD UNIVERSITY	96006
SALFORD UNIVERSITY	82316
SALFORD UNIVERSITY	159665
SALFORD UNIVERSITY	163874
SHEFFIELD UNIVERSITY	54563
SHEFFIELD UNIVERSITY	115129
SHEFFIELD UNIVERSITY	967000
SHEFFIELD UNIVERSITY	183577
SHEFFIELD UNIVERSITY	128040
SHEFFIELD UNIVERSITY	50785
SHEFFIELD UNIVERSITY	112310
SOUTHAMPTON UNIVERSITY	228003
SOUTHAMPTON UNIVERSITY	4492
SOUTHAMPTON UNIVERSITY	21100
SOUTHAMPTON UNIVERSITY	5875
SOUTHAMPTON UNIVERSITY	129933
SOUTHAMPTON UNIVERSITY	106785
SOUTHAMPTON UNIVERSITY	157415
STRATHCLYDE UNIVERSITY	190079
STRATHCLYDE UNIVERSITY	215019
STRATHCLYDE UNIVERSITY	49573
STRATHCLYDE UNIVERSITY	175815
STRATHCLYDE UNIVERSITY	199285
STRATHCLYDE UNIVERSITY	173198

Appendix 4

SUSSEX UNIVERSITY	50474
THE UNIVERSITY OF SURREY	133955
THE UNIVERSITY OF SURREY	222055
UMIST	82927
UMIST	40941
UMIST	51798
UMIST	65093
UMIST	145445
UMIST	50230
UMIST	138334
UNIV WALES, ABERYSTWYTH	139570
UNIV WALES, SWANSEA	252008
UNIV WALES, SWANSEA	118681
UNIV WALES, SWANSEA	250244
UNIV WALES, SWANSEA	153834
UNIVERSITY COLLEGE LONDON	91129
UNIVERSITY COLLEGE LONDON	40823
UNIVERSITY COLLEGE LONDON	157560
UNIVERSITY COLLEGE LONDON	48530
UNIVERSITY COLLEGE LONDON	214648
UNIVERSITY COLLEGE LONDON	148666
UNIVERSITY COLLEGE LONDON	142926
UNIVERSITY COLLEGE LONDON	1665
UNIVERSITY OF MANCHESTER	3400
UNIVERSITY OF MANCHESTER	38064
UNIVERSITY OF MANCHESTER	142680
UNIVERSITY OF MANCHESTER	60494
UNIVERSITY OF WALES, CARDIFF	48473
UNIVERSITY OF WALES, CARDIFF	119933
UNIVERSITY OF WALES, CARDIFF	51359
UNIVERSITY OF WALES, CARDIFF	197867

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UNIVERSITY OF WALES, CARDIFF	140993
UNIVERSITY OF WALES, CARDIFF	137859
WARWICK UNIVERSITY	107291
WESTMINSTER UNIVERSITY	41051
WESTMINSTER UNIVERSITY	135356
YORK UNIVERSITY	99943
TOTAL	20712760

UNIVERSITY OF WALES SWANSEA, CIVIL ENGINEERING DEPARTMENT

Survey on

The Use of Computer Simulation in Industry

This questionnaire is relevant to companies that are involved with computational simulation

Thank you for your co-operation

Prepared by Z. Zheiri
e-mail: cgzheiri@swansea.ac.uk

Under the supervision of
Professor N. P. Weatherill
Head of Department

The Department of Civil Engineering at the University of Wales Swansea is rated as **5* in research and 'Excellent' in teaching**. It has earned an international reputation for developments in the field of computer based simulation

Appendix 5

UNIVERSITY OF WALES SWANSEA, CIVIL ENGINEERING DEPARTMENT

1. Are you aware of computer simulation for engineering problems Yes/No

   If you are not aware, would you be interested in receiving information Yes/No

   If you are interested, please give your name and address

   Name .....

   Address .....

   .....

2. Please specify the financial profile of your company.

Turnover of the company (£ million)	≤0.1	≤0.5	≤1	≤10	≤30	≤50	>50
1995							
1996							
1997							
1998							

Turnover related to computer simulation (£ million)	≤0.05	≤0.2	≤0.5	≤5	≤15	≤25	>25
1995							
1996							
1997							
1998							

Gross profits of the company (as a percentage of turnover)	≤2%	≤5%	≤15%	≤25%	≤30%	≤40%	>40%
1995							
1996							
1997							
1998							

Gross profits of the company related to computer simulation (as a percentage of turnover)	≤0.02%	≤0.05%	≤1%	≤5%	≤10%	≤15%	>15%
1995							
1996							
1997							
1998							

3. Please tick, as appropriate, yearly expenditure of the company on computer resources (as a percentage of **turnover**)

Expenditure of the company on:	≤5%	≤15%	≤25%	≤35%	≤45%	≤55%	≤75%	>75%
Software & Maintenance								
1995								
1996								
1997								
1998								
Hardware & Maintenance								
1995								
1996								
1997								
1998								

Expenditure related to computational simulation on:	≤1%	≤5%	≤10%	≤15%	≤25%	≤40%	≤65%	>65%
Software & Maintenance								
1995								
1996								
1997								
1998								
Hardware & Maintenance								
1995								
1996								
1997								
1998								

4. Please specify the profile of employment in your company.

Total number of employees	≤10	≤20	≤100	≤300	≤500	≤700	≤1000	>1000
1995								
1996								
1997								
1998								

Appendix 5

UNIVERSITY OF WALES SWANSEA, CIVIL ENGINEERING DEPARTMENT

Number employed on computer simulation	≤5	≤10	≤20	≤50	≤100	≤200	≤500	>500
1995								
1996								
1997								
1998								

5. Please tick, as appropriate, the research budget of your company (as a percentage of **turnover**)

Internal R&D budget	≤2%	≤5%	≤10%	≤15%	≤25%	≤35%	≤40%	>40%
1995								
1996								
1997								
1998								
Internal R&D budget for computer simulation	**≤0.005%**	**≤0.02%**	**≤5%**	**≤10%**	**≤15%**	**≤30%**	**≤40%**	**>40%**
1995								
1996								
1997								
1998								

External R&D budget	≤2%	≤5%	≤10%	≤15%	≤25%	≤35%	≤40%	>40%
1995								
1996								
1997								
1998								
External R&D budget for computer simulation	**≤0.005%**	**≤0.02%**	**≤5%**	**≤10%**	**≤15%**	**≤30%**	**≤40%**	**>40%**
1995								
1996								
1997								
1998								

Appendix 5

UNIVERSITY OF WALES SWANSEA, CIVIL ENGINEERING DEPARTMENT

Total R&D budget (Internal & External)	≤2%	≤5%	≤10%	≤15%	≤25%	≤35%	≤40%	>40%
1995								
1996								
1997								
1998								
Total R&D budget for computer simulation (Internal & External	**≤0.005%**	**≤0.02%**	**≤5%**	**≤10%**	**≤15%**	**≤30%**	**≤40%**	**40%**
1995								
1996								
1997								
1998								

Please tick as appropriate:

6. Have you purchased computer simulation software in the last three years? Yes/No
   If Yes, which did you consider the most appropriate
   a. Short term benefit b. Long term benefit c. Others (please specify)

7. Have you sold computer simulation software in the last three years? Yes/No
   If Yes, which did you consider the most appropriate
   a. Short term profit b. Long term profit c. Others (please specify)

8. For your computational simulation, who did you rely upon for provision in the last three years?
   a. Universities b. Software Houses c. Both d. Others (please specify)

9. How was computational simulation viewed in your company last year?
   a. Very important b. Important c. Not important d. Don't know

10. Is your company prepared to invest more in computational simulation this year?
    a. Yes b. No c. Probably d. Probably not e. Don't know

*** Would you be prepared for us to contact you for further information? Yes/No**
If yes, please specify a contact name and address.

Thank you for completing this questionnaire!